PROCEEDINGS

WATER RESOURCES AND ENVIRONMENT:

Education, Training and Research

"Using Educational Programs To Solve Water And Environmental Management Problems"

Conference and Workshops

July 13-17, 1992
Colorado State University
Fort Collins, Colorado

Information Series No. 69
Colorado Water Resources Research Institute

Colorado State University

CONFERENCE PROCEEDINGS

WATER RESOURCES AND ENVIRONMENT: EDUCATION, TRAINING AND RESEARCH

"Using Educational Programs to Solve Water And Environmental Management Problems"

July 13-17, 1992
Colorado State University
Fort Collins, Colorado

Organized and Sponsored by
Department of Civil Engineering
and
Colorado Water Resources Research Institute

Colorado State University Organizing Committee

Neil S. Grigg, Chair
Berhane M. Abraha
Carolyn Early
Verdia Johnson
Janet Montera
Jorge Ramirez
Robert Ward

Colorado Water Resources Research Institute
Information Series No. 69

PROGRAM

FINAL PROGRAM

WATER RESOURCES AND ENVIRONMENT: EDUCATION, TRAINING AND RESEARCH

July 13-17, 1992

Colorado State University
Fort Collins, Colorado

<u>*Monday, July 13, 1992*</u>

8:00-10:00 AM *{A104 Clark}*	*Registration and Coffee*
10:00-10:20 *{A104 Clark}*	***Welcoming Session***
	Welcome: Francis A. Kulacki, Dean *College of Engineering* *Colorado State University*
	Conference Procedure: Neil S. Grigg, Head *Department of Civil Engineering* *Colorado State University*
10:20-12:00 N *{A104 Clark}*	***Session I: (Plenary) Keynote Addresses*** *Moderator: Marvin Jensen* *Colorado Institute for Irrigation Management* *Colorado State University*

"Major Issues in Water Resources for the 90's"
Evan C. Vlachos, Sociology and Civil Engineering Departments, Colorado State University

"Major Issues in Environment for the 90's"
J. Eleonora Sabadell
National Science Foundation, Washington DC

"A Vision for Education in Water Resources and the Environment"
Neil S. Grigg, Colorado State University

12:00-1:30 PM ***Lunch non-hosted***

1:30-3:00 ***Session II: (Plenary) Major Issue Papers***
{A104 Clark} *Moderator: Eleonora Sabadell*
National Science Foundation

"Issues in Water Resources Education"
James P. Heaney, Civil, Environmental, and Architectural Engineering, University of Colorado, Boulder

"Issues in Environmental Education"
George Walker, Office of Environmental Education, Environmental Protection Agency, Washington DC

"Issues in Minority Education"
Norbert Hill, American Indian Science and Engineering Society, Boulder, Colorado

3:00-3:30 ***Coffee Break***

3:30-5:00 ***Session III: (Plenary) Major Issue Papers***
{A104 Clark} *Moderator: David Freeman*
Department of Sociology
Colorado State University

"Issues in International Water Resources Education"
Alan C. Early
Agricultural and Chemical Engineering Department, Colorado State University

"Issues in Water Resources Research"
Ari M. Michelsen
Wyoming Water Resources Center, University of Wyoming, Laramie

"Issues in Water Resources and Environmental Outreach"
W. Dennis Lamm
Cooperative Extension for State of Colorado, Colorado State University

5:15-6:30 ***Reception*** *- The College of Engineering*
{University Club} *is pleased to host this reception*

Tuesday, July 14, 1992

7:30-8:30 AM *Registration*
{A104 Clark}

8:30-10:00 ***Session IV: (Plenary) Education in Water Resources***
{A104 Clark} *Moderator: Al Dyer*
College of Natural Resources
Colorado State University

"Education for Solution of Forthcoming Water Resources Problems"
Vujica Yevjevich, Department of Civil
Engineering, Colorado State University

"The Role of Training in Institutional Development:
Egypt Water Research Center"
M.A. Abu-Zeid, Water Research Center, Cairo
D.K. Sunada, Department of Civil Engineering,
Colorado State University

"The Waterways Experiment Station Graduate Institute:
An Educational Partnership"
C.H. Pennington, WES Graduate Institute,
R. W. Whalin, USAE WES, Vicksburg, Mississippi

10:00-10:30 ***Coffee Break***

10:30-12:00 ***Session V-A: Education in Water Resources and Environment***
{A104 Clark} *Moderator: Maurice L. Albertson*
Department of Civil Engineering
Colorado State University

"Water and Environmental Engineering Education, Training and Research
at Tampere University of Technology, Finland"
Jaakko Puhakka, Paivi Makinen and Matti Vittasaari,
Institute of Water and Environmental Engineering, Tampere
University of Technology, Tampere, Finland

"Curriculum Issues in Applied Hydrology and the Environment"
Mary Jessica Mack, Department of Geography and Environmental Studies, University of Colorado, Boulder

"The Water Resources within Civil Engineering Education in the University of the Americas-Pueblo, Mexico"
Octavio Cabezut Boo, Mechanical and Civil Engineering Department, Universidad de los Americas, Puebla, Mexico

"Hydrologic Education: The Need for a Field Component"
Lee H. MacDonald, Department of Earth Resources, Colorado State University

10:30-12:00
{A202 Clark}

Session V-B: Computers in Water Resources Education
Moderator: Timothy K. Gates
Department of Civil Engineering
Colorado State University

"Rule Based Computing in Water Resources: An Alternative to Procedural Languages"
Johannes Gessler, College of Engineering, Colorado State University

"Educational Software for Reservoir Management"
Darrell G. Fontane and John W. Labadie
Department of Civil Engineering, Colorado State University

"User Friendly Computer Packages in Education: A Case Study-The Flodro Package"
Jose A. Raynal-Villasenor, Universidad Autonoma de Chihuahua, Carlos A. Escalante-Sandoval, Universidad Nacional Autonoma, de Mexico

10:30-12:00
{A203 Clark}

Session V-C: Outreach Programs in Water and Environment
Moderator: Lloyd Walker, Extension
Agricultural and Chemical Engineering Department
Colorado State University

"The Groundwater Education in Michigan (GEM) Program"
Jessica T. Kovan, W.K. Kellogg Foundation
Linda W. Helstowski, Institute Water Research,
Michigan State University

"An International Approach to Great Lakes Education"
Sally Cole-Misch, Public Affairs,
Beverley Croft, Information/Education
International Joint Commission
Detroit, Michigan and Windsor, Ontario

"Water Educators for Public Awareness"
John Kaliszewski, Colorado Division of Water Resources
Barbara Preskorn and Russell Perron,
Front Range Community College, Westminster, Colorado,

12:00-1:30 PM ***Lunch non-hosted***

1:30-3:00 ***Session VI-A: Education in Water Resources and Environment***
{A104 Clark} *Moderator: Jorge Ramirez*
Department of Civil Engineering
Colorado State University

"A Novel Program for the Master's Degree in Hydraulic Engineering in the Universidad Autonoma de San Luis Potosi"
Daniel Fco. Campos Aranda, and Arturo Difurt-Candelaria,
Universidad Autonoma de San Luis Potosi, Mexico

"Experiential Learning in Hydrology at Colorado Mountain College"
Peter Jeschofnig, Colorado Mountain College, Leadville

"The Colorado Commission on Higher Education Water Resources Program of Excellence at Colorado State University"
Laurel Saito, Department of Civil Engineering,
Colorado State University

"Urban vs. Rural Conflicts: The Economic and Environmental Advantages of Water Marketing"
Laura Puryear Finnell, University of Idaho, Moscow

1:30-3:00 **Session VI-B: Outreach Programs in Water and Environment**
{A202 Clark} *Moderator: Carolyn Early*
Colorado State University

"WET and the Watercourse: New Programs in Water Education for the Future"
Susan Higgins, The Western Watercourse,
Montana State University, Bozeman

"Extending Knowledge on Agricultural Water Quality Issues: The Role of Colorado State University Cooperative Extension"
Lloyd R. Walker, Department of Agricultural and
Chemical Engineering, Colorado State University

"A Review of Primary and Secondary Water Resource Education Curricula of the Atlantic Coastal States"
Barry W. Fox, Virginia State University, Petersburg

3:00-3:30 ***Coffee Break***

3:30-5:00 ***Workshops***

{A104 Clark} *A. Education in Water Resources and Environment*
Chair: C.H. Pennington
Reporter: Darrell G. Fontane

{A202 Clark} *B. Outreach Programs in Water and Environment*
Chair: Beverly Croft
Reporter: Dennis Lamm

Wednesday, July 15, 1992

7:30-8:30 AM {A104 Clark}	*Registration*
8:30-10:00 {A104 Clark}	***Session VII: (Plenary) Educational Issues***

Moderator: Neil S. Grigg
Department of Civil Engineering
Colorado State University

"Army Environmental Policy Institute Interaction with Historically Black Colleges and Universities and Minority Institutions"
Kristan Cockerill-Kafka, Department of the Army, Environmental Policy Institute, Champaign, Illinois

"The Five-Stage Pipeline of Teacher Professionalism and Empowerment"
Fredrick Stein, Center for Science, Mathematics and Technology Education, Colorado State University

"Environmental Education in Engineering: A New Paradigm for the 90's"
Francis A. Kulacki, College of Engineering, Colorado State University

10:00-10:30 ***Coffee Break***

10:30-12:00 {A104 Clark} ***Session VIII-A: Environmental Case Studies***

Moderator: Kristan Cockerill-Kafka
Department of the Army
Environmental Policy Institute
Champaign, Illinois

"Teaching and Research in Environmental Waste and Water Quality Management (EW/WQ) Programs at Alabama A&M University"
Sunnie A. Aburime, Robert W. Taylor and Jeanette Jones, Department of Plant and Soil Science, Alabama A&M University, Normal

"Toxic Communications and Assistance Project"
Ellis E. Sykes and David C. Robinson, Albany State College, Albany, Georgia

"Environmental Degradation of Greater Dhaka City"
M. Habibur Rahman, Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh

"Water Quality Remediation of Acid Mine Drainage Using Wetlands: A Case Study in Carbondale, Ohio"
Subramania I. Sritharan and Victor I. Okereke, International Center for Water Resources Management, Central State University, Wilberforce, Ohio

10:30-12:00
{A202 Clark}

Session VIII-B: International Water Resources Education
Moderator: Dan K. Sunada
Department of Civil Engineering
Colorado State University

"Adaptive Research and Training Needs for Sustainable Water Use in Agriculture"
Arumugam Kandiah, Land and Water Development, FAO, Rome

"Towards Sustainability in Water Sector in Developing Countries--Challenges for Engineering Education"
Pekka E. Pietila, Tapio S. Katko, and Osmo T. Seppala
Tampere University of Technology, Tampere, Finland

"Appropriate Water Resources and Environmental Engineering Training for International Development"
Berhane M. Abraha, Civil Engineering Department, Colorado State University

"Environmental Engineering, Training and Research at the University of Dar es Salaam, Tanzania"
D. A. Mashauri, Faculty of Engineering, University of Dar es Salaam, Tanzania

"A Water Resources Graduate Program in Colombia: Experience and Needs"
Ricardo A. Smith, Dario Valencia and Oscar J. Mesa, School of Mines, National University of Colombia, Medellin, Colombia

10:30-12:00 *{A203 Clark}* ***Session VIII-C: Research in Water Resources***

Moderator: Dan King
U.S. Bureau of Reclamation
Denver, Colorado

"Program of the National Institutes for Water Resources"
Steven P. Gloss, Wyoming Water Resources Center,
University of Wyoming, Laramie
Henry J. Vaux, Jr., Water Resources Center,
University of California, Riverside,
Howard S. Peavy, Montana Water Resources Research
Center, Montana State University, Bozeman

"Environmental and Water Resources Engineering Research at the Waterways Experiment Station"
F.A. Herrmann, Hydraulics Laboratory,
J.R. Houston, Coastal Engineering Research Center,
J. Harrison, Environmental Laboratory,
USAE Waterways Experiment Station, Vicksburg, Mississippi

"Use of GIS in Studying Water Main Breakage Problems"
Emmanuel U. Nzewi, Department of Civil Engineering,
Subhasis Mukherjee, Department of Industrial Engineering
North Carolina A&T State University,
Greensboro, North Carolina

"Incompleteness of Wastewater Dechlorination"
Anthony C. Nweke and George R. Helz
Department of Chemistry and Physics
Norfolk State University, Norfolk, Virginia

12:00-1:30 ***Lunch non-hosted***

1:30-3:00
{A104 Clark}

Session IX-A: Water Resources and Environmental Education

Moderator: Emmanuel Nzewi
Department of Civil Engineering
North Carolina A&T State University
Greensboro, North Carolina

"Environmental Engineering Education by the Video Classroom"
David G. Parker, Civil Engineering,
University of Arkansas, Fayetteville

"Groundwater Contamination and Remediation: A Module of Instruction"
Bradford H. Spring, Department of Civil Engineering,
Valparaiso University, Valparaiso, Indiana

"MINTEQA2 As a Chemical Speciation Model for Use in Soil and Water Investigations"
W. L. Lindsay, Department of Agronomy, Colorado State University

1:30-3:00
{A202 Clark}

Session IX-B: International Case Studies

Moderator: Darrell Fontane
Department of Civil Engineering
Colorado State University

"Small Dams in Africa: Health Impacts"
R. Klees, A. Long, E. Crowley, I. Degoga, H. Daou, M. Konare
Environmental Health, USAID, Washington, D. C.

"Education, Training, and Research for Effective Management of Coastal Resources of the Yucatan, Mexico"
S.D. Oaks, Earth Resources, Colorado State University
G. de la Cruz, CINVESTAV, Unidad Merida, Yucatan, Mexico
L.G. Lopez-Lemus, PRONATURA Peninsula de Yucatan

"Computer Assisted Water Resources Education and Training"
Azad Mohammadi, Amirkabir Univ. of Technology, Tehran, Iran

"Water Industry, Education, Training and Research in Kenya"
Maurice Mbeda Ndege, Department of Civil Engineering,
University of Nairobi, Kenya

3:00-3:30 ***Coffee Break***

3:30-5:00 ***Workshops***

{A104 Clark} *A. Research in Water Resources and the Environment*
Chair: Steve Gloss
Reporter: Dan King

{A202 Clark} *B. International Water Resources and the Environment*
Chair: Sunnie Aburime
Reporter: Victor E. Okereke

5:30-6:30 ***Reception***
{West Ballroom
Lory Student Center}

6:30 ***Banquet***
{West Ballroom
Lory Student Center} ***Water in the West: A Local Perspective***

Thursday, July 16, 1992

7:30-8:30 AM *Registration*
{A104 Clark}

8:30-10:00 ***Session X: (Plenary) Minority Education in Water Resources and Environment***
{A104 Clark}

Moderator: Omnia El-Hakim
Department of Engineering and Physics
Ft. Lewis College, Durango, Colorado

"Water Resources Consortium for Historically Black Colleges and Universities"
Fathy M. Saleh, Center for Energy and Environment, Virginia State University, Petersburg, Virginia.

"Minority Education and Involvement in Water Resources"
Victor I. Okereke, International Center for Water Resources Management, Central State University, Wilberforce, Ohio

"Minority Institutions Collaboration Program in Water Resources and Environmental Management"
Berhane M. Abraha, Department of Civil Engineering, Colorado State University

10:00-10:30 ***Coffee Break***

10:30-12:00 ***Session XI: (Plenary) Minority Education in Water Resources and Environment***
{A104 Clark}

Moderator: Victor Okereke
International Center for Water Resources Management
Central State University, Wilberforce, Ohio

"Mentoring: The Key to Attracting and Retaining Minorities and Women in Collegiate Engineering Programs"
Bradford S. Price, Policy Development Branch, U.S. Army Corps of Engineers, and Mary Ellen Chafin, Executive Director, Buffalo-area Engineering Awareness for Minorities (BEAM)

"Minority Engineering And Research Project"
Omnia El-Hakim, Department of Engineering and Physics,
Ft. Lewis College, Durango, Colorado

"Overview of Minority Student Recruitment and Retention Programs at Florida International University in Environmental Science and Engineering"
Berrin Tansel, Civil and Environmental Engineering Department,
Florida International University, Miami, Florida

12:00-1:30 ***Lunch non-hosted***

1:30-3:00
{A104 Clark}

Session XII: (Plenary) Minority Education in Water Resources and Environment

Moderator: Fathy Saleh
Center for Energy & Environmental Studies
Virginia State University, Petersburg, Virginia

"Unique Problems Faced by Minority Institutions Educators
Emmanuel U. Nzewi, Department of Civil Engineering
North Carolina A&T State University
Greensboro, North Carolina

"Use of Multimedia Technology in Engineering Instruction"
Huey K. Lawson, Acting Chair and
Erat S. Joseph, Department of Civil Engineering,
Southern University, Baton Rouge, Louisiana

"Opportunities with Federal Agencies"
Owen Williams, Water Resources Division
National Park Service, Fort Collins, Colorado

Other Federal Agency Representatives

3:00-3:30 ***Coffee Break***

3:30-5:00 ***Workshops***

{A104 Clark} *A. Minority Issues in Water Resources and Environmental Education*
Co-Chairs: Sunnie Aburime/Omnia El-Hakim
Reporters: Bradford S. Price/Kristan Cockerill-Kafka

{A202 Clark} *B. International Water Resources and the Environment: Latin America*
Co-Chairs: Jorge Ramirez/Sherry Oaks

Panel Presentations:
Need for a Latin American Center for Science and Technology Cooperation

Mechanisms for Establishing Scientific and Technological Cooperation

7:00-9:00 ***FORUM OF HBCUs/MIs for WATER RESOURCES AND ENVIRONMENTAL MANAGEMENT CONSORTIUM***
{B206 Engineering Building}
Moderator: Neil S. Grigg,
Department of Civil Engineering
Colorado State University

<u>*Friday, July 17, 1992*</u>

Moderators: *Neil Grigg/Berhane Abraha*
Department of Civil Engineering
33Colorado State University

8:30-10:00 ***SESSION XIII: (Plenary) Workshop Summations and Recommendations for Action***
{A104 Clark}

A. Education in Water Resources and Environment
Reporter: Darrell Fontane

B. Outreach Programs in Water and Environment
Reporter: Dennis Lamm

C. Research in Water Resources and the Environment
Reporter: Dan King

10:00-10:30 ***Coffee Break***

10:30-12:00 ***SESSION XIV: (Plenary) Workshop Summations and Recommendations for Action***
{A104 Clark}

A. International Water Resources and the Environment
Reporter: Victor E. Okereke

B. International Water Resources and the Environment: Latin America
Reporters: Jorge Ramirez and Sherry Oaks

C. Minority Issues in Water Resources and Environmental Education
Reporters: Bradford S. Price and Kristan Cockerill-Kafka

12:30 ***Closing Luncheon*** *- Neil Grigg*
{West Ballroom
Lory Student Center}

GUIDELINES

WATER RESOURCES AND ENVIRONMENT
Education, Training and Research

Workshop Guidelines

The general goal of the workshops is to generate new thinking about needed directions for education policy, programs and methods in water and environmental education. One workshop will focus on the roles of minority institutions and another on international opportunities and needs.

Each workshop will prepare a brief report to the plenary session about the findings. The findings will be responses to a set of questions and will include reports on what the participants thought were important issues and solutions. On Friday, all of the workshop findings will be published for the group, and additional issues and recommendations will be solicited from the attendees.

The following are some of the questions to be directed to the workshops. Additional questions and issues should be formulated by the attendees.

EDUCATION IN WATER RESOURCES AND ENVIRONMENT

1. What are the emerging needs and challenges to improve water resources management through hydrology and water resources education?

2. Given today's concern about the environment, what are the needed contributions to environmental management from education?

3. What is included in hydrology and Water resources education?

4. What are the main recommendations of recent reports about water resources education? Have they been implemented? Why or why not?

5. Is hydrology and water resources an engineering subject, or interdisciplinary?

6. What courses should be required in engineering curricula, both water resources and environmental?

7. What is the role of federal and state agencies in promoting water and environmental education?

8. What is a definition of environmental education?

9. What are the reports of recent task forces? How can they be implemented?

10. What are the links of environmental education with water resources education?

11. What are the disciplinary inputs to environmental education?

12. What are the roles of computers, telecommunications and modern technologies in water and environmental education?

MINORITY INSTITUTIONS

1. What are the unique opportunities and challenges for Historically Black Colleges and Universities?

2. How can networks be formed? What can they do?

3. Are there logical cooperative patterns? Should HBCU's be doing more with African universities; western universities doing more with Mexico?

4. What are the opportunities to work in international development?

5. How can universities help more with K-12 problems, and with socio economic problems in general?

6. Is there strength in diversity? Can we improve water and environmental management by introducing ideas from other cultures?

7. What are the interests of federal agencies in working with HBCU/MI's? How can a consortium be formed to facilitate this?

8. What will be it's specific goals?

9. What is the best way of managing the Consortium?

10. What are the technical areas of engagement by the Consortium?

11. How many should collaborate in the Consortium as members;
Is there an optimum size of the Consortium?

12. Capabilities and resources study of the HBCUs and MIs.

OUTREACH

1. What are the needs for improved public education, continuing education, distance earning and outreach for water and environmental issues?

2. What forms of outreach are appropriate for today's universities?

3. What should be the roles of different levels of institutions, university, community college, K-12?

4. How should outreach be funded?

RESEARCH

1. What are the main issues needing research? How did UNSED, the recent international conference at Rio de Janeiro affect our perception of environmental issues?

2. Is the funding base adequate for water and environment?

3. What is the role of the federal government in financing and conducting research?

4. Is the decline in federal funds for water resources research a serious problem? At the National Science Foundation, for example?

5. Should there be more fellowships and student support?

6. How are the WRRI's doing?

INTERNATIONAL ISSUES

1. With the world shrinking due to communications, how can institutions cooperate more? What are current trends in international cooperation?

2. What are the international problems of water and environment that education can help solve?

3. What has been learned through international cooperative efforts such as IHP, Water and sanitation decade, etc.

4. Are there special opportunities and responsibilities for US institutions to cooperate with African universities, Latin American institutions, etc?

5. How can the international and bilateral agencies help in such cooperation?

6. How can education, training and research be improved in developing countries?

PROCEEDINGS

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SESSION VII: (Plenary) EDUCATIONAL ISSUES

SESSION VIII-A: ENVIRONMENTAL CASE STUDIES

SESSION VIII-B: INTERNATIONAL WATER RESOURCES EDUCATION

SESSION VIII-C: RESEARCH IN WATER RESOURCES

SESSION IX-A: WATER RESOURCES AND ENVIRONMENTAL EDUCATION

SESSION IX-B: INTERNATIONAL CASE STUDIES

SESSION X: (Plenary) MINORITY EDUCATION IN WATER RESOURCES AND ENVIRONMENT

SESSION XI: (Plenary) MINORITY EDUCATION IN WATER RESOURCES AND ENVIRONMENT

WATER RESOURCES AND ENVIRONMENTAL EDUCATION
Using education to meet environmental challenges
and to create opportunities

Conference Results
Colorado State University
July 13-17, 1992

SYNOPSIS

The conference, Water Resources and Environment: Education, Training and Research, was held July 13-17, 1992 at Colorado State University. The need for the conference was driven by the growing seriousness of environmental issues, societal problems and international implications. The focus was on using educational programs to solve water and environmental problems. Special sessions were also devoted to the roles of minority institutions and to international linkages. About seventy attendees represented universities, outreach organizations, federal agencies and international organizations. Sixty two papers were presented, and six workshops were held.

The broad nature of water and environmental educational programs was recognized. Educational programs must focus on the most important opportunities and prepare graduates for jobs in the real world. Each program must find a niche. Courses should emphasize integration of social issues with technical solutions and have more focus on international issues. Programs need to be more real world and practical, and contain more lab work and field experiences. There should be more teamwork, less duplication, and more cooperation to make up for the loss of resources. Government can reduce its fragmentation and work to further education at all levels, including citizen education. Organization of a national commission to review water and environmental education might be considered.

Funds for research are at a low level, and there are many complaints that needed funds are not available. However, the nation's ability to support its entire educational enterprise must be considered, as well as the need to provide funds to minority institutions. Industry sources, as well as government, should be sought. Increased funding to HBCU/MIs should be provided through consortia.

In outreach, role definition is needed to clarify the most productive uses of resources, especially for universities, and higher education's ability to finance outreach should be assessed. Incentives to faculty members should be evaluated. The roles of the Cooperative Extension program in water and environmental education especially need clarification. Minority institutions can build community recognition by engaging in outreach programs, but they need assistance to get started.

Internationally, universities should cross cultural boundaries and work together more effectively in water and environmental education, but financial and political problems face educational institutions desiring to help. The US is reducing its Africa portfolio at a time when water and environmental needs in Africa are vast, and the potential for cooperation with HBCU's is good.

Problems of minority institutions include lack of funds, low levels of support, high teaching loads, perceptions that minority institutions are small in size and purpose, low salaries, and related management issues. Solutions can include: equipment donation programs, establishment of industry-university loan programs for faculty, organization of consortia, programs for research initiation at MI's, increase in salaries, and funds to support sabbaticals, assistantships and other needs in the universities. Emphasis should be placed where HBCU/MIs have unique opportunities and responsibilities, and international linkages should be extended.

Desired outcomes for the conference included working to formulate better curricula; making higher education affordable by forming consortia and increasing productivity and opportunities for students, faculty and institutions; teaming up to deliver programs of education, research and outreach/training; looking for opportunities for students and helping them to finance and enrich their educations; and focusing on diversity goals. During the conference a lot of networking occurred, plans for a consortium in water and environmental education were laid, a proposal for a program was presented, and knowledge about the issues was shared. The full proceedings of the conference, including all papers, workshop reports and summary will be published. It is possible that followup meetings will be held, but plans are not definite yet. All participants have greater understanding of the issues in water and environmental education.

VISION FOR THE CONFERENCE

Solutions to water and environmental management problems must be based on professional competence and responsive systems of government. These are only possible with an informed citizenry and when effective educational systems are in place for all citizens, including minority groups.

Educational systems include pre-school, K-12, higher education, lifelong professional education and education for the public. Universities have special roles in providing degree programs and continuing professional education, and to be partners with government agencies and private organizations in meeting their educational and training needs. There are special roles and opportunities for institutions serving minority populations.

Two sets of problems and challenges created the need for the conference and accompanying workshops: growing awareness of the seriousness of environmental issues, and parallel awareness that not all citizens are sharing equally in the opportunities and responsibilities to solve the problems. These are broad, societal issues that cannot be easily solved; however, making progress on them will be at the heart of the nation's social, economic and environmental agendas. The problems extend beyond the borders of the United States; thus another goal of the conference was to discuss the international implications of the challenges and to identify ways that nations can cooperate in the issue areas of environment, education and the creation of opportunity.

Conferees contributed papers and thoughts in workshops over a period of four and a half days. The overall results of the conference are summarized in this working paper. Also published are the workshop summaries and the conference papers.

ENVIRONMENT, EDUCATION, OPPORTUNITY

Environmental management. Water and related environmental problems are certainly high among the major resource issues facing the planet, and education has much to contribute to resolving the problems. Evan Vlachos and Eleonora Sabadell presented the challenges at the conference.

Vlachos summarized the water problems by stating that water is fundamental to all life forms, affects all ecosystems, and is spatially and seasonally unevenly distributed; it's use inherently creates conflicts relating to both water quantity and quality. During the past 20 years, our search for solutions has placed emphasis on the environmental challenges, on the quest for sustainable development, on the promotion of integrated planning and management and the attempt to apply non-structural and well as structural measures to find solutions. Vlachos showed how societal transformations were responding to the changing times with conceptual breakthroughs, advances in methodologies, mobilization of organizations and generation of new substantive concerns about issues such as climatic shift, dam safety and toxic spills, socio-political changes, transboundary problems and fast paced technological change. He concluded by emphasizing that a transformation of paradigms from unlimited resources to sustainable development is necessary.

Sabadell reminded us that environmental problems are still mounting. She observed that responses to environmental problems in the US and elsewhere had included identification, evaluation, and mitigation of environmental risks, with laws and regulations that have had mixed success, often at great cost. Discussion and evaluation of these problems have taken place at numerous conferences and reports, including the UN Conference on Environment and Development (UNCED), held in Rio in June 1992, 20 years after the first international conference on the environment at Stockholm, Sweden. Sabadell predicted that chemical contamination will continue, but at declining levels; that gains will be made in developed countries in energy conservation; that greenhouse gases will continue to increase with potential climate change; and that biological and toxic substances contamination may grow in the absence of effective regulation. She stated that to develop positive advances in attacking these problems decisionmakers will have to recognize the human dimension, along with chemical and physical aspects of contamination, if we are to succeed in reclaiming the quality of our planet's environment. This will require strong political will, innovative economic approaches, leadership in all countries and the settlement of transboundary disputes. She observed that the limited and uneven distribution of knowledge and education is one of the main causes of environmental decay, with apparent results being the vicious cycle of poverty, uncontrolled population growth, poor land use, resource exploitation, unsafe technologies and proliferation of hazardous sites.

As a result of Vlachos' and Sabadell's papers, the formidable challenges faced in the environmental field and the many faceted roles of education to ameliorate the problems were evident. These are critical policy issues for the US, as observed recently in the Wall Street Journal: "...the environment may become the hottest issue of the '90's, superseding political or cultural differences as a source of international tension ... Americans of all persuasions should commit themselves to making the world a better place when the millennium ends. A safe ecological environment may have as much strategic importance in 2000 as a stable political environment does in 1990" (Wall Street Journal, January 1, 1990).

Education. Education may well be the top social policy issue in the US, along with meeting the needs of an increasingly diverse population. At the conference, education was taken in a broad sense to include knowledge generation (research) and transfer (including outreach). It focused primarily on the role of higher education, but interpreted this role broadly to include linkages with and roles of K-12 through graduate training.

Education for water and environmental management must prepare managers and workers for the industries and agencies that have responsibility to manage water and the environment. Also, the public and their elected and appointed officials require education, training and appropriate knowledge to make informed decisions.

To deal with water and environmental problems, students need aptitudes for science and mathematics, and other skills, primarily management and communication, are also necessary. In the US, much concern has been expressed about science and math education. A great deal of attention is being given to this problem, which is wrapped up in the overall problem of K-12 education in the country. General K-12 educational issues being discussed in the country include the need for national assessments, accountability, choice, parental responsibility, local control, and support for preschool children. These fundamental educational issues are the focus at the K-12 level, and higher education is expected to contribute to addressing them, along with other societal and economic sectors.

Universities are going through an identity crisis, searching for roles. Time magazine recently devoted a cover story to it: "The College Crunch: strapped for money, educators are reinventing the university for the 21st century" (Time, April 13, 1992). Time stated "By the year 2000, American colleges and universities will be lean and mean, service oriented and science-minded, multicultural and increasingly diverse - if they intend to survive their fiscal agony." A policy study presented the challenges as driven by a new economic age, a science-driven economy, changing mores and families, changing demographics driven by aging, diversity, and economic disparities, and shifting economic centers and urban organization paradigms. College presidents in a survey listed main issues as: minority participation in higher education, financing higher education and making it affordable, replacing qualified faculty, helping the US keep its competitive edge, making governance and leadership work and improving the public schools (Gilley, 1991).

The focus on a competitive edge and science-driven economy will intensify the need for environmental education, as well as to provide workplace opportunities for graduates. Changing population mixes and increasing diversity signals us to be sensitive to how we can respond to the changes. These, and other socioeconomic issues, created the focus for the conference.

With regard to the specific aspects of university level education in water resources and environment, some of the questions to be addressed at the conference included: what are the emerging challenges in hydrology and water resources education; what are the needed contributions to environmental management from education; what are the recommendations of recent reports about water resources education and have they been implemented; is hydrology and water resources an engineering subject, or interdisciplinary; what courses should be required in various curricula, both water resources and environmental; what are the roles of federal and state agencies in promoting water and environmental education; what is environmental education and what are the reports of recent task forces; what are the links of environmental education with water resources education; and what are the roles of computers, telecommunications and modern technologies in water and environmental education?

Concerning outreach, some of the specific questions and issues included: what are the needs for improved public education, continuing education, distance learning and outreach for water and environmental issues; what forms of outreach are appropriate for today's universities; what should be the roles of different levels of institutions, university, community college, K-12; and how should outreach be funded?

Research is a particular concern in environmental education. Specific issues to be addressed included: what are the main problems needing research; how did the recent international conference at Rio de Janeiro affect our perception of environmental issues; is the funding base adequate for water and environment research; what is the role of the federal government in financing and conducting research; is the decline in federal funds for water resources research a serious problem; should there be more fellowships and student support; how are the state water research institutes doing, and are they making the needed contributions?

Finally, with regard to international opportunities, some specific questions arose: with the world shrinking due to communications, how can institutions cooperate more; what are current trends in international cooperation; what are the international problems of water and environment that education can help solve; what has been learned through international cooperative efforts such as IHP and the Water and Sanitation Decade; and are there special opportunities and responsibilities for US institutions to cooperate with African universities, Latin American institutions, and Asian institutions?

<u>Opportunity</u>. The United States has worked to assimilate minority populations for many years and its population is becoming more culturally diverse. One of the principal issues facing the nation is how to adapt to the coming changes and how to create a more just society in the process. The 1950's and 1960's saw a profound and successful civil rights movement that is still going on. Finding more opportunity for women in the workplace is an

important national goal, and accommodating citizens from different national origins continues to be an important national priority.

Minority citizens and institutions have the same commitment to the environment as majority citizens and institutions, and women have a deep interest in the environment, and in some cases, as in international development, they have special roles and opportunities for education and outreach. Given this level of interest and potential, it follows that opportunities for minority citizens and institutions as well as women can be enhanced in the environmental field(s).

There is much interest in matching minority institutions with national environmental aims and goals, but the persistent problems of minority institutions and populations have impaired progress. One of the goals of the conference was to search for ways to improve this situation, to make progress in creating opportunities for minorities and women in the environmental fields, and to utilize these opportunities to create more effective partnerships with majority institutions and international organizations.

Some of the specific questions to be raised at the conference included: what are the unique opportunities and challenges for Historically Black Colleges and Universities; how can networks be formed and what can they do; are there logical cooperative patterns, should BCD's be doing more with African universities and western universities doing more with Mexico, for example; what are the opportunities to work in international development; how can universities help more with K-12 problems, and with socio-economic problems in general; is there strength in diversity of ideas, can we improve water and environmental management by introducing ideas from other cultures; what are the interests of federal agencies in working with HBCU/MI's; how can a consortium be formed to facilitate this?

CONFERENCE PRESENTATIONS

<u>Environmental and water resources education</u>.

General. The keynote paper by Heaney (Issues in Water Resources Education, James P. Heaney) told us that although water resources has been a critical issue for a long time, the term only emerged as a
descriptor in the 1960's with the Water Resources Research Act. Heaney defined water resources as an applied multidisciplinary field involving engineering, natural science, social science. Now there are graduate programs at over 100 universities.

As history, Heaney traced the development of systems analysis from the 1950's, showing that it is now an integral part of water resources management. The environmental movement of the early

1970's shifted our attention to give students better background in water quality and ecology, but, according to Heaney, it forced a deemphasis on the social sciences, particularly economics, because benefit cost analysis not a part of major environmental legislation. The hydrologic sciences may be the focus of the 1990's due to attention to climate change and other factors. Heaney stated that water resources education will continue to be driven by an applied focus, but that competition will increase and there will probably not be room for over 100 graduate programs. Heaney saw the need to introduce concepts of total quality management into the curriculum, and with the shift to a focus on undergraduates, more attention to lab work is needed.

Vujica Yevjevich presented an address and paper entitled "Education for Solution of Forthcoming Water Resources Problems." He used the following nine topics to illustrate the point that changes in education are needed: focus on pollution and protection; demand for decrease of pollution has tranformed planning and operation; river runoff can be used to monitor climate change; water resources development can be used to fight climate change; aging of structures presents special challenges; need for well trained specialists to maximize production of water; risk aversion of societies creates need for risk analysis and management; conflict will increase and must be managed; reallocation of water rights will require new techniques; drinking water issues focus public attention on health. The lead, according to Yevjevich, to a need for revisions in education, and society will demand more cooperation between protection and development.

Curriculum and programs. To respond to the challenges in water and environmental education, numerous innovations are being tried. At Colorado State University, for example, Frank Kulacki described the approach adopted for environmental engineering education, after a task force study recommendation. The approach involves a new specialization in environmental engineering science with the students being able to take a second major in chemical engineering or civil engineering. At the same time, the College of Engineering will continue to offer master's degrees in environmental engineering in several departments.

Colorado State retains a separate approach to offering water resources education. Laurel Saito described the Program of Excellence in Water Resources supported at Colorado State University by the Colorado Commission on Higher Education. This includes graduate programs in hydraulics, hydrologic science and engineering, groundwater, environmental engineering, water resources planning and management and irrigation and drainage.

Numerous specific examples of individual programs or courses were presented at the conference, and these are described briefly in the following paragraphs. Please refer to the conference proceedings for the full papers.

Courses, computers teaching innovations. Darrell G. Fontane and John W. Labadie presented information about software they have developed at Colorado State University to teach about research operation. Azad Mohammedi presented an analysis of computer assisted water resources education and training. Johannes Gessler showed how computing can be improved and the lost time devoted to computing reduced (Gessler, Johannes, Rule Based Computing in Water Resources: an alternative to procedural languages). Jose A. Raynal and Carlos A. Escalante presented a paper about user friendly packages for education that focus on floods and drought.

The use of the video classroom for environmental education was described by David G. Parker.

Mary Jessica Mack presented a paper about Curriculum Issues in Applied Hydrology and the Environment. It illustrated how a multifaceted course could be presented in the context of a department of geography and environmental studies.

The need for field and lab work was illustrated by Lee H. MacDonald, in his paper (Hydrologic Education: the need for a field component). Bradford H. Spring described a groundwater contamination and remediation module of instruction used at the undergraduate level in environmental education. It illustrated how some imagination can go a long way in meeting the need for lab work.

Education centers and new programs. James Pennington described the master's program of the US Army Waterways Experiment Station, carried out in conjunction with four universities. The Army established an Environmental Policy Institute in 1990 (AEPI). As described by Kristan Cockerill-Kafka, AEPI is a policy research institute with a limited mission to aid Historically Black Colleges and Universities and minority institutions.

M. Abu-Zeid and Daniel K. Sunada described the ongoing activities at the Egypt Water Research Center. Strengthening programs were initiated in 1976 as a result of cooperation between Egypt and USAID. As a result of three different projects, the technical and management expertise of the staff of the WRC has been significantly strengthened, and the staff members are making contributions through research and technology transfer in other parts of the world.

Finland has initiated water and environmental engineering education at the Tampere University of Technology (Puhakka, Jaakko, Paivi Makinen, S. Sandelin and M. Viitasaari, Water and Environmental Engineering Education, Training and Research at Tampere University of Technology, Finland). Programs for developing countries are included, and a special program in environmental engineering for Eastern Europe will begin in 1992. Emphasis on environmental biotechnology will increase in 1993.

Daniel Fco. Campos-Aranda and Arturo Difurt-Candelaria described the master's program in hydraulic engineering at the Autonomous University of San Luis Potosi. The program began in 1980 with an emphasis on water resources planning, evolved into one with an emphasis on hydraulics and now is moving toward more emphasis on environmental subjects.

Sunnie Aburime described the program of teaching and research in environmental waste and water quality management as it is carried out at Alabama A&M.

D.A. Mashauri described the environmental engineering program at the University of Dar Es Salaam, Tanzania. The program goes back to about 1969 and involves cooperation with Germany. The paper identifies some modernization needed in the environmental areas.

Ricardo A. Smith, Dario Valencia and Oscar J. Mesa wrote about the a water resources graduate program at the School of Mines, National University of Colombia, Medellin. The program has done well, but has needs that include; to maintain PhD level teachers in spite of low salaries; to maintain an adequate library; to keep current with computers and software; to obtain research funding; and to stay in touch with peer institutions.

Sherry Oaks, G. de La Cruz and L.G. Lopez-Lemus contributed a paper about education about coastal resources of the Yucatan in Mexico.

Maurice M. Ndege described the water industry, education, training and research issues in Kenya.

Octavio Cabezut-Boo presented data about civil engineering education at the University of the Americas at Puebla, Mexico.

Peter Jeschofnig described a program for experiential learning for hydrologic technicians at Colorado Mountain College.

<u>Research.</u>

The conference aimed to study research needs and policy, but this turned out to be too ambitious a topic. Nevertheless, some research policy issues, activities and needs were identified.

Steve Gloss presented a description of the program of the National Institutes for Water Resources and showed how the federal program is the "glue" that holds the national network together. Ari M. Michelsen presented a paper about issues in water resources research. He showed that based on the experience of the water institutes, the future issues will focus on water quality, groundwater, management and planning and policy and law.

The US Army's Waterways Experiment Station's research program was described by F.A. Herrmann, Jr., J.R. Houston and J. Harrison. WES is involved in a wide variety of water resources research and project investigations related to the Army's civilian and military missions related to water resources, environment and coastal resources.

Outreach.

Outreach is a very diverse topic. W. Dennis Lamm introduced the topic at the plenary session with a paper entitled "Issues in Water Resources and Environmental Outreach." He described changes in the cooperative extension activities, and how Extension had changed from the only provider of information to a new role as a broker, networker, facilitator, and coordinator of data delivery.

George Walker reported about the Environmental Education Act and activities under EPA, including that EPA has $6.5 million in appropriations for environmental education, with emphasis on the grants program. They also develop training programs for professionals, administer fellowship programs and provide information to a wide span of agencies and actors.

As case study examples of outreach programs and needs, several papers described different approaches. Jessica T. Kovan and Linda W. Helstowski described Michigan's "Groundwater Education in Michigan" (GEM) program. Sally Cole-Misch and Beverley Croft presented a paper about the International Joint Commission's approach to Great Lakes Education. John Kaliszewski, Barbara Preskorn and Russell Perron contributed a paper about the need for water education for public awareness in Colorado. Susan H. Higgins described the program Wet and the Watercourse: new programs in water education for the future. Wet stands for water education for teachers. Ellis E. Sykes described the toxic communications and assistance project undertaken at Albany State College, one of the HBCU's.

Activities of the Colorado State University Cooperative Extension Service were described by Lloyd R. Walker. Barry W. Fox presented a review of primary and secondary water resource education curricula used by the Atlantic Coastal States, also an Extension activity.

International issues.

Alan and Carolyn Early presented a paper to lead off the discussion about international issues in water resources and environmental management. They identified seven issues: stage of development and economic growth rate; current level of technology; resource base of the nation; stated national priorities; existing administration and legal framework; national set of values and customs; and national will and commitment to change. The issues for educators are then, how to we address education within the context of these seven issue areas? Berhane M. Abraha presented a paper about the appropriate water resources and environmental training for international development.

Pekka E. Pietila described the challenge of reaching sustainability in the water sector, the challenges to engineering education. The twinning approach was recommended as a useful technique for institutional assistance.

Arumugam Kandiah, representing FAO, presented adaptive research and training needs for sustainable water use in agriculture. He showed that new technologies and improvements in human resources development are needed to help countries to help themselves.

As an example of health problems faced in developing countries, Rita Klees and others contributed a paper about the health impacts of small dams in Africa.

Minority institution issues.

To lead off the discussion of forming a consortium of minority institutions to work on water and environmental problems, several papers provided specific insight into the issues.

Berhane Abraha presented a description of the need for a minority institutions collaboration program in water resources and environmental management. Fathy Saleh described a suggested approach developed as a result of a meeting at Virginia State University. Emmanuel U. Nzewi described the unique problems faced by minority institutions educators.

In the way of specific programs, Victor I. Okereke presented a description of the program in water resources management at Central State University. Omnia El-Hakim described activities in Colorado to encourage Native Americans in the study of engineering. Berrin Tansel presented an overview of the minority student recruitment and retention programs at Florida International University. Huey K. Lawson and Erat S. Joseph presented a paper about the use of multimedia technology in engineering education and the coalition for improving the quantity and quality of undergraduate engineers, including minorities.

Special approaches are needed to meet the needs of minorities. For example, the role of mentoring was described by Bradford S. Price and Mary Ellen Chafin. These techniques will, of course, aid all students desiring to continue into higher education.

CONCLUSIONS

Conference conclusions came from the workshop sessions and from a study of the papers.

Education in water resources and environment

The global focus on economic competitiveness and the science-driven economies will intensify the need for environmental education and provide new and different work and professional opportunities. How can water and environmental education adapt?

Both water and environmental subject areas are broad. Both include engineering and non-engineering aspects. Heaney defined water resources as an applied multidisciplinary field involving engineering, natural science, social science, and Kulacki showed that environmental engineering is a broad subject covering several disciplines of engineering. The term "environmental science" shows how broad the educational focus on the environment can be. To respond, educational programs must be focused on the most important disciplinary and interdisciplinary clusters of knowledge and professional opportunities.

In responding to these challenges and opportunities it is necessary to focus both on the subject matter and on the preparation of graduates for jobs in the real world. The reason that engineering has dominated is that it offers jobs. While this will continue, the job market will also diversify, with more emphasis on science, management, law and related fields.

Heaney pointed out that the term water resources has only been used for about 25 years, and that it will be difficult for all of the current graduate programs to survive and prosper. The waves of emphasis have focused successively on water resources, environment, water quality and ecology, hazardous waste and now hydrologic sciences. Heany saw the need to adapt principles of TQM to water management, and to respond to the need for focus at the undergraduate level with attention to lab work. Yevjevich used nine topics to illustrate his point that changes in education are needed and that society will demand more cooperation between protection and development in the future.

Each program of water or environmental education will have to find its own niche; there will be no common formula for all. However, each can make contributions toward resolving the apparent needs.

One need is for courses to emphasize integration of social, political, legal and related issues along with technical solutions. We believe that technical solutions, with some exceptions, may be ahead of societal solutions, but a focus on societal factors is critical to prepare students for the years ahead.

Courses need to have more focus on international issues. The globe is shrinking and there exist many possibilities to cooperate across boundaries, to use international case studies, and to understand the need to resolve transboundary conflicts.

Courses should cover a broader span of subject matter, be more global in subject matter. This is necessary to integrate the knowledge from different disciplines into new curricula and programs. There should be courses on water and environment for non-engineers. These must be fashioned both to inform the non-engineers about the issues, and to prepare scientists and managers for careers in environmental fields.

Educational programs need to be more real world and practical. Undergraduates and graduate students should be exposed to more lab work and field experiences.

To respond to current and future financial limitations, there should be more teamwork, less duplication, and more cooperation to make up for the loss of resources. This can help twin US and international institutions and help meet the needs of minority institutions as well as majority institutions with shortfalls in resources. Also, better use of information technologies, video and telecommunications technologies can make education more effective and to make funds go further.

The need for citizen education about the environment is becoming more obvious all the time. Universities have an obligation to work with the K-12 system to help prepare teachers and students for the science-driven world, with emphasis on environmental solutions.

Government can help by reducing its own fragmentation and competition. Going to an organizational model of a single DNR at both the state and federal levels would help. Then the DNR's could work with the educational system to further education at all levels.

Research

The research support enterprise in water and environment drives graduate education, provides equipment and facilities for universities to teach undergraduates. Graduate education provides the competent graduates needed to fill faculty positions, staff labs and occupy positions that require higher level skills. Today, however, funds and opportunities for research seem to be at a low level, and there are many complaints that needed funds are not available.

Of course, the lack of funds for research in universities has been a national policy issue cutting across all subject areas, and there are valid policy questions about the need for the funds in a time of fiscal austerity. For example, do we need to be producing more scientists and engineers, do we need more big science or more small science, are we overbuilt with universities, etc?

Investments in human resources can never be counter-productive, but it is possible to produce more graduates than there are jobs for, and this possibility must be weighed against the genuine need for scientists, engineers and a more educated populace in general. Also, the need to provide funds to minority institutions to raise their opportunities must be addressed in the research enterprise.

The work group on research recognized these questions. They focused on funding, social/geopolitical/economic factors, educational priorities and linkages for coordination and communication.

For funding, they suggested that industry sources, as well as government, be sought. Research benefits must be publicized more to decision makers. Increased funding to HBCU/MIs should be provided through consortia. They suggested that duplication should be eliminated and that priorities should be established. Finally, they suggested that basic research should be funded without mission orientations, and that a concept such as a national institute for the environment might help.

In the social/geopolitical/economic category, they focused on some of the same issues as the education group: increased attention on non-engineering factors, more attention to global issues, more focus on community and K-12 education and making the needed changes to respond to societal needs. They also suggested more application of team teaching, innovation in teaching, emphasis on practical experience and retaining basic science.

With regard to minority institutions, they suggested that they could find niches and affiliate with government agencies to find opportunities. Increased awareness of opportunities for minorities should be promoted, and linkages should be established to promote opportunities.

The research group made an interesting suggestion about government's role: organization of a national commission to review water and environmental education.

Outreach

Outreach has many dimensions, and role definition is needed to clarify the most productive uses of resources. For example, it is necessary to define who has responsibility to develop and evaluate curriculum material. Science and non-science issues must be translated into lay terms.

The question of agency commitment to outreach is an important one. Also, value content of outreach material is a controversial question. Some believe that outreach material is intended to brainwash students and the public.

The new roles of the nation's Cooperative Extension program are still evolving, but it is clear that it has a role in water and environmental education, especially as it relates to the K-12 system and to natural resources management in general.

The mission of universities relative to outreach needs more attention. With the financial problems of universities and higher education in general, can it afford to do much outreach? Also, what is the role of the tax-assisted university versus the non-profit private voluntary organization? What about the incentives to faculty members, considering the "publish or perish" syndrome? Can better incentives for outreach be built into the systems?

Minority institutions can build up more community recognition by engaging in outreach programs, but they need the ability to get started. They may have to compete with larger universities who also need the recognition.

International issues

International challenges and possibilities for water and environmental education are as complex as the plethora of global development issues that were discussed at UNCED and at other international conferences. How, for example, can we cross cultural boundaries and work together more effectively to solve water and environmental problems through education? How can educational institutions contribute to the solutions needed?

Financial and political problems face educational institutions desiring to help. For example, the US is apparently reducing its already small Africa portfolio to begin focusing on Eastern Europe, but water and environmental needs in Africa are vast, and the potential for cooperation with HBCU's is good.

Political issues include the lack of good channels of communication within developing countries. For example, if materials are sent to the ministry, that might not be enough to get them to local institutions that need them.

(note: workshop notes on international issues are being prepared)

A workshop was also held on the possibilities of developing more cooperation with Latin America through a proposed Latin American Center for Science and Technology Cooperation (LACSTC). Notes on the concept are attached.

Minority institutions

Problems and opportunities of minority institutions were discussed extensively at the conference. Nzewi, for example, highlighted some of the resource and other limitations, including lack of funds, low levels of support, high teaching loads, perceptions that minority institutions are small in size and purpose, low salaries, and related management issues.

Nzewi suggested as solutions the development of donation programs, establishment of industry-university loan programs for faculty, organization of consortia, programs for research initiation at MI's, increase in salaries, and funds to support sabbaticals, assistantships and other needs in the universities.

The workshop on minority institution issues identified extensive opportunities available to HBCU/MIs. Notes from the workshop are attached. Some of the more impressive opportunities are: form consortia, increase resources, build on strengths, work on K-12 issues where HBCU/MIs have unique opportunities and responsibilities, and extend international linkages.

NEXT STEPS

In the introduction to the conference, Grigg made the observation that two sets of problems and challenges created the need for the conference: growing awareness of environmental issues and that all citizens should share in the resulting opportunities and responsibilities. He identified the following six issue categories to study: links between higher education and K-12, student support programs, faculty development, curriculum, research and dissemination of knowledge. Additional questions included: can consortia contribute to achieving the goals we have identified; are coordinated national strategies in environmental education needed; what kind of international linkages will promote our goals; what is the need for focused centers for research and outreach; how can the needed programs be financed; and how can higher education and K-12 work better with the private sector?

Grigg stated that the hoped outcomes could include: working together to formulate better curricula to respond to society's needs; working to make higher education affordable by forming consortia and using technologies and cooperation to increase our productivity and increase opportunities for students, faculty and institutions; teaming up to plan and deliver the needed programs of education, research and outreach/training; looking for ways to increase opportunities for students in the environmental fields, helping them to finance and enrich their educations; and focusing on diversity goals to find ways to respond genuinely to societal environmental and opportunity needs.

During the conference a lot of networking occurred. Plans for a consortium of HBCU/MIs in water and environmental education were advanced and firmed up. A proposal for a program is under discussion with federal agencies. Much knowledge about the nature of the problems was shared.

Next steps include the next steps to form an effective consortium. These will be discussed in the minutes of a meeting held during the conference to advance the consortium. Also, the full proceedings of the conference, including all papers, workshop reports and this summary will be published and made available. It is possible that followup meetings will be held, but plans are not definite yet. Finally, all participants now have greater understanding of the issues we face in water and environmental education, increasing opportunities in these fields and in promoting cooperation between institutions to work on these problems.

SUMMARY OF DISCUSSION AT THE WORKSHOP ON EDUCATION IN WATER RESOURCES AND ENVIRONMENT

Chair: C.H. Pennington
Reporter: Darrell G. Fontane

The workshop was conducted by focusing on four of the suggested twelve questions for this topic identified in the Guidelines section of the conference proceedings. The questions were considered one at a time, and each workshop participant was given the opportunity to respond to the question. The responses of the group to these questions are summarized as follows:

1. [Question 1.] What are the emerging needs and challenges to improve water resources management through hydrology and water resources education?

Responses -

* Courses in water resources engineering lack adequate coverage and integration of social, political, legal and other related non-engineering relevant issues. The multi-disciplinary aspects of water resources and environmental management need to have greater stress. The point was made that in most situations, the water resources and environmental problems are not engineering problems (or the engineering problems could be readily solved) but rather they are human problems (social, political, etc.) There is a need to incorporate human relationship building and effective communication skills as part of the education process. Education should become more "team-based" and integrated inter-disciplinary courses should be encouraged. There should be courses in water resources offered for non-engineers.

* Courses in water resources and environmental management should have a more global focus. These comments had two general areas of meaning. Global can be used to mean "international or world". In this context there should be emphasis on the concept of sustainable water resource projects. There should also be more attention to differences in needs in developed and developing nations and an international perspective. More attention should be given as to how to adopt technology to developing countries. There should be increased attempts to promote exchange and interaction among international faculty and professionals. Global focus was also used to mean a broader or holistic view. In this context there is need to see water resources and environmental management not only as "engineering or remediation" projects but in the broader viewpoint of the entire process of water use, waste generation, etc. Courses should have more focus on emerging issues since the education process is educating people to solve future problems. Similar comments were also made with respect to hydrology. Our courses need a broader view of hydrology to encompass large (global) scales and time scales in decades.

* Courses in water resources and environmental management need to

have a more practical or real world focus. There should be a good evaluation of the relevance of the education system to producing graduates that can solve real world problems. There is a need for more field experience and opportunities to link "classroom" models with practical application. Increased interaction with practitioners might be one way to help. Similar comments were made with direct reference to hydrology. Exchange of ideas should be promoted among hydrologists from engineering and non-engineering backgrounds. Field experience for hydrologists should be enhanced and hydrology education should have a stronger practical focus.

* The higher education process needs to streamline/reorganize to emphasize team efforts, to avoid duplication and to make more effective use of information technologies. There is a need to improve and strengthen transfer of technology. There is a need to have a reasonable number of graduate students for the faculty available. There are problems in attracting science and engineering students and faculty and there needs to be more focus on academic achievement to get students into these fields.

2. [Question 2.] Given today's concern about the environment, what are the needed contributions to environmental management from education?

Responses -

* There needs to be a societal focus on environmental management. There is a strong need to create public awareness of the environment. This process must begin at home at the family level and should be reinforced by more environmental education in grades K-12. University curriculum also need to be modified to focus on environmental management (for example require a course on ecology).

* The school system is not in sync with societal needs. There need to be a revamping of secondary education to greatly enhance the teaching of science and mathematics to include practical experience, intern programs, environmental projects, ecology courses, etc. Universities could contribute by helping develop and conduct programs for the K-12 school system.

* The scale issues discussed in the first question are also relevant. The educational process must cover both large scale environmental issues as well as small scale issues. For example, small farmers/businesses need education on simplified technologies for small scale non-point source pollution management.

3. [Question 7.] What is the role of federal and state agencies in promoting water and environmental education?

Responses -

* There is a need for a single Department of Natural Resources at the federal and state level. This would eliminate the competition and duplication of effort that current exists with multiple

agencies involved in water resources and environmental management. It would also serve to better focus government efforts.

* There is a need for state agencies to take a greater role in identifying educational needs for K-12 and universities. State agencies could also be more politically active in pushing for required educational changes. Educational/government/private advisor committees, partnerships, and other mechanisms should be more effectively used to identify educational needs. The educational needs should focus on promotion of policy not only on technological needs. The Waterways Experiment Station Graduate Institute is a good model that might be considered by other agencies and universities.

* Federal and state agencies hold public meetings on water resources and environmental projects and they should consider holding some of the meeting in K-12 schools as a method of educating children. Also environmental awareness programs developed by children can be effectively used to educate adults.

4. [Question 12.] What are the roles of computers, telecommunications and modern technologies in water and environmental education?

Responses -

* The use of computer and information technology for environmental education should be encouraged/expanded both nationally and internationally. These technologies are the wave of the future.

* Telecommunications and video courses can be used to supplement traditional education processes. This will be particularly valuable to developing countries that are in the process of building their educational system. A video tape of a lecturer is really not using the advantages of the media. A video tape that supplements the lecturer with real world examples, field trips, etc. is much more exciting and relevant. Attempts should be made to make the telecommunication education process more interactive and enhance student - teacher contact. The use of telecommunications and video (for example, "how-to" presentations) are particularly effective in areas with low literacy. These technologies can be effectively used for education of children.

* The use of computing technologies should be used to enhance the educational process. This is important in improving the education of math and science in the U.S. Computing technologies such as computer visualization and animation provide a ways to illustrate environmental processes that are not observable in nature and promote understanding. However, computer education has to address the need to have a practical reference. For example, students should still learn the basics of manual calculations so that they are not total dependant on a computer to perform simple tasks.

WORKSHOP SUMMARY

Outreach Programs in Water and Environment

Beverly Croft, the chair of this Tuesday afternoon workshop, challenged the eight individuals present with additional questions to those previously offered in the notebook. She questioned us on such things as: do we practice what we preach?; are we environmentally friendly?; where does brainwashing begin?; how do we defend our values without being defensive?; what is sustainable development?; are we storytellers?; are we passing on our culture and values?

We raised numerous questions as we discussed training curriculum in outreach to pre-college audiences. We discussed what are our responsibilities and who is responsible for evaluating this training curriculum? We need a holistic (science/non-science) approach to teaching. We need to put science in terms the lay public can understand, essentially the model Extension uses to take research-based information and convert it into user-friendly information for the general public.

We discussed our dealings with the media and press as to how objective we should be versus how objective we can be; what is the line that we draw so we are not "preaching" to the media.

We also questioned how committed our respective agencies are to addressing water and environmental issues. Are they forced to because there are dollars available to drive the programs, or is there personal commitment which allows individuals and agencies to address issues? Another question was what is our definition of "environment"? It probably varies by individual.

We further discussed the need for curriculum clearinghouses. Huntsville, Alabama was mentioned as having an excellent clearinghouse. The international committee that Beverly is working on has recommended a clearinghouse to be at least partially funded by the U.S. Congress.

We decided we cannot change bureaucracies so we need to highlight the small successes and individual achievements rather than waiting for bureaucracies to change. We also decided we needed to use models that are currently working. The Ohio State University and Tufts University were mentioned as models who have had success in environmental education.

Someone mentioned the possibility of changing the title from "Environmental Education" to "Natural Resources Education." This individual felt there would be more grassroots understanding of this terminology.

We raised the question as to how outreach should be funded and discussed the role of community colleges. We decided because of their present focus on narrow objectives, community colleges are not offering interdisciplinary type efforts or communication.

What forms of outreach are appropriate for universities? We felt they could be responsible for developing curriculum. Using present infrastructures, such as Cooperative Extension, could be very effective in outreach programs. Unfortunately, we discussed the negative attitudes toward university outreach and decided that perhaps the role and mission of the university in general needs to be reviewed. We do not need to reinvent the wheel, but instead use existing mechanisms and delivery systems such as the Cooperative Extension and/or Continuing Education models as outreach entities of the land-grant university.

In summary, we felt pre-college outreach is critically needed in the Environmental Education and Water Resources areas; that the public-at-large also needs information and this information needs to be presented in an understandable manner.

We stressed the importance of networking among all agencies and individuals in an effort to stretch resources and produce a quality product.

Funding for outreach is a challenge and may be available from multiple sources if networking among agencies can occur. It is important to use key words that are in vogue as a way to attract attention and, subsequently, financial resources.

A suggestion was made that perhaps at a future conference such as this, a multi-agency grant proposal could be started and developed as a focus of the conference. No consensus, however, was reached for this suggestion.

Submitted by,

Dennis Lamm, Reporter

WORKSHOP ON "RESEARCH IN WATER RESOURCES AND THE ENVIRONMENT"

Chair: Steve Gloss
Reporter: Danny King

Chairman Steve Gloss suggested that we follow a structured brainstorming process, asking that each participant submit three problems in each of two categories: (1) Institutional/Policy problems and (2) Environmental/Technical problems.

The submittals were discussed and combined into a list of 12 problems for Institutional/Policy and 13 problems for Environmental/Technical.

The Institutional/Policy problems were categorized as:

- Funding
- Social/Geopolitical/Economic
- Educational Priorities
- Linkages for Coordination and Communication

Each participant then submitted solutions/approaches for each of the categories, which were then combined into a list of several solutions for each category.

Time did not permit additional work on the list of Environmental/Technical problems.

WORKSHOP ATTENDERS

Emmanuel U. Nzewi
Paul Abrahams
Charles D. Whyte
Huey K. Lawson
Darrell G. Fontane
Robert W. Taylor
Steve Gloss
Frank A. Herrmann, Jr.
Fathey M. Saleh
Sri Sritharan
Bradford H. Spring
Ramble Ankumah
Danny King

INSTITUTIONAL/POLICY

1. Funding prioritization
2. Environmental equity (siting facilities, etc.)
3. Manpower needs assessment
4. Insufficient funding
5. Education/research conflicts
6. Lack of interdisciplinary research
7. Linkages among government/industry/academe
8. Funding for minority faculty and students
9. Research duplication (HBCU and other schools)
10. International environmental realities
11. Jobs vs. environment
12. Need to emphasize basic physics (tendency may be toward de-emphasis)

Main Categories

A. Funding (1,4,8)
B. Social/Geopolitical/Economic (2,10,11)
C. Educational Priorities (3,5,6,12)
D. Linkages for Coordination and Communication (5,7,9)

Solutions

A. Funding
- ¤ Other funding (e.g. industry)
- ¤ Publicize research benefits to decision makers
- ¤ Increased HBCU/MI funding (incl. consortia)
- ¤ Eliminate duplication and establish priorities to increase funding
- ¤ Fund basic research without mission orientation (national institutes for environment?)
- ¤ Redirect peace-dividend funds

B. Social/Geopolitical/Economic
- ¤ Increase attention to these factors in teaching, particularly international and global
- ¤ Apply risk analysis to problems
- ¤ Structural changes
- ¤ Programs to involve disadvantaged in conflict resolution
- ¤ More public education (e.g. community awareness conferences)
- ¤ Expose primary and secondary students to environmental impact concepts

C. Educational Priorities
- ¤ Emphasize basic and applied via team teaching
- ¤ Pilot innovative educational approaches
- ¤ National commission to review water and environmental education
- ¤ Emphasize practical experience in what is taught
- ¤ Retain more basic science in curriculum
- ¤ Identify niches for HBCUs/MIs and small academic institutions (coop with govt agencies and prof. societies
- ¤ Increase awareness of opportunities for minorities

D. Linkages for Coordination and Communication
- ¤ Networking with HBCUs and others
- ¤ Cooperative research with HBCUs and others
- ¤ Exchange programs
- ¤ National water resources and environmental research data base (already underway)

ENVIRONMENTAL/TECHNICAL

1. Groundwater contamination
2. Long-term studies in air/water; public health emphasis
3. Infrastructure rehabilitation
4. NPS pollution
5. Efficient technologies - GIS, conservation, reuse
6. Environmental policy research and training
7. Increase emphasis on computer hardware instead of software
8. Climate change
9. Use of management models by industry
10. Endangered species - socioeconomic considerations
11. Research on priority problem identification (research planning)
12. Technology commercialization
13. Basic research vs. problem solving

(NOTE: Time did not permit additional work on this list of problems.)

Workshop on International Water Resources and the Environment

Chair: Sunnie Aburime
Reporter: Victor Okereke

The group decided to take on the six questions raised in the "Instructions" for this particular workshop. The chairman started off by asking each participant to express their thoughts on each question. That proved to be unworkable and we went into an open discussion of the issues.

Below is a summary of the ideas put forward by members of the group and the discussions that followed.

1. How can institutions cooperate more? What are the current trends?

Coordination of the work of all the players in the field is critical. This is particularly important with the international agencies, the non-governmental organizations, the national and local government agencies. This problem has already been recognized by many of the players. Hence, some level of interagency coordination has already been put into place. However this is not nearly enough.

What is most needed though was increased coordination of activities within the national and local governments of the developing countries. Mexico, already has introduced increased coordination of its governmental units. Even within the United States government, there is lack of coordination in water resources issues, resulting in a multitude of agencies that have some jurisdiction over water. Years ago it was recommended that a federal department of natural resources be formed to take responsibility for all water issues, but nothing came of the recommendation.

The collaboration between Colorado State University, the Egyptian Government and the Egyptian Water Center was cited as an excellent example of good collaboration and of the benefits it can bring to all involved.

Developing countries must be willing to accept modern technology from the developed countries. The "donor" countries must also develop better expertise about the developing countries and their needs before recommending projects or throwing money at problems.

Officers and technical experts of the developed countries need training in appropriate technologies. It is recommended that the "donor" countries should refrain from using experts who are ignorant of the local customs, culture and language.

It is not very encouraging that a lot of people depend on government to make things happen. Since governments come and go and their policies change, it would be best to reduce the current reliance on government to make things happen especially in a critical area like water resources. Often a new government may be hostile to the cause. For instance, President Reagan tried to eviscerate the Environmental Protection Agency when he came to power in 1981.

Of course, there can't be any cooperation without politics. It drives everything. Hence, there is a need to educate government officials about needs.

Communications need to improve between the U.S. government and developing countries. Right now it tends to be a one-way street: from Uncle Sam to the "small brother" and not vice versa.

Practitioners must note that things will change slowly and therefore need to be patient. Things are the way they are because of history. We should not expect to change 2,000-3,000 year practices overnight.

2. How can education help solve international problems of water and the environment?

Universities as well as other educational institutions can help. They can teach. They can produce the appropriate technical materials and literature. Education in water resources, the environment and other health-related areas should start early. Universities should change and adopt their curriculum to the needs of the developing countries that they serve.

Problem solving education should be emphasized. Ways must be found to control and/or reduce the "brain drain." Education of developing country nationals paid for by national governments, non-governmental organizations and by foreign governments must be structured in a way to prevent the so-called brain drain.

In the end the group agreed with the sentiment expressed by one of the members who said: "Education can solve everything."

3. What has been learned through cooperative efforts such as IHP, Water and Sanitation Decade?

The developed and developing countries have learned and gathered a heap of data. But there is little dissemination and use of this data. A mechanism should be devised to disseminate the information that is already available.

IHP, Water and Sanitation Decade have identified these problems and progress has already been made in the area. Lessons learned have also included what not to do, the need to be involved in the community we serve and the need to involve host country nationals in all phases of any development projects. This should be the case in water resources as well as in any other sector including the environmental program.

4. Are there special opportunities and responsibilities for U.S. institutions to cooperate with African and Latin American institutions?

The greatest role for American universities would be the dissemination of results and problems encountered in problem solving in the United States and elsewhere. They can also help by publishing reports of their work and making them more available to people who can use them. This is particularly important because many agencies tend to hoard information. It gives them power. The use of the mass media should never be overlooked in this regard.

What most developing countries need is information not money. So, U.S. universities can help by giving them useful technical information. Of course, such information should be both relevant and appropriate.

5. How can the international and bilateral agencies help in such cooperation?

The group felt that the answer to this question is imbedded in the others and moved o to question #6,

6. How can education, training and research be improved in developing countries?

The group felt that:

- Education should start early with mom and dad and should never lack a building block at any level.

- Educators should listen to local people and relate to them on equal terms. That is the best way to influence people and effect needed changes.

- Local leadership should never be overlooked in any facet of the educational system and process.

- Developing countries should come to the developed countries with an agenda, a shopping list of their needs. That is the only way they can hope to get anything out of their relationship with the developed nations.

- Structure foreign student education in the U.S. to facilitate smooth reentry into their societies when they return home.

- Develop linkages between American and developing country universities to facilitate technology transfer.

Summary of Workshop - International Water Resources and the Environment: Latin America

The goal of the workshop was to discuss the proposed Latin American Center for Science and Technology Cooperation (LACSTC). The idea of a center as originally suggested by Sherry Oaks, Earth Resources Department of Colorado State University to colleagues at CSU and at other institutions, was to create a mechanism for closer on-campus cooperation between faculty in the Colleges of Natural Resources and Civil Engineering, and others who are specifically interested in Latin America, particularly on the issues involving resource conservation and natural hazard mitigation. The original concept focused upon establishing partnerships with colleagues at institutions in Latin America.

The management of the environment and the management of economic development are issues of prime importance for balancing human growth needs and environmental limits of sustainable development. The increasing losses from natural hazards in Latin America is indicative that development practices are not sustainable.

Sustainable development and hazard mitigation are interconnected. During the 1990's U.N. International Decade for Natural Disaster Reduction (IDNDR), the ability to cope with routine disasters may be enhanced if resource management and hazards management can be integrated. Sustainable development can be bolstered by disaster reduction; hazard mitigation can help shape "safer" development. Hazards management is a subset of environmental management, but it is a key subset in a region where single disasters reduce a decade of development gains or where conditions of poverty and debt erode the resilience of human and environmental systems daily.

The focus of the center is proposed to include education, training, and research in these areas of resource management and hazards management. As contained in the original proposal presented at the conference workshop (see below) the center would focus on cooperative opportunities and joint ventures between CSU and colleagues at universities, centers, institutes, governmental entities, non-governmental organizations, and other institutions in Latin America.

The support for the idea of the center appeared unanimous in the workshop comments from colleagues in Latin America present at the workshop. Colleagues at CSU reiterated the goals of joint development of research projects and "new directions" for "sustainable, culturally and environmentally sensitive intellectual alliances." The strengths of the CSU campus in water resources, natural resources, and other related fields including environmental health and natural hazards, along with capabilities in remote sensing and GIS applications, provide an integrated scientific and technological base for collaborative research, education, and training initiatives and cooperation with interested parties.

A partial list of organizations and entities interested in cooperative ventures with the LACSTC include:

1. Centro de Investigacion y Estudios Avanzados de Unidad Merida, Mexico and Pronatura de Yucatan, Mexico,

2. U.S.-Latin American Partnership, a consortium of U.S. and Latin American organizations focused on natural hazard mitigation,

3. Center for Latin American Studies - University of Florida,

4. Hazard Reduction and Recovery Center - Texas A&M University,

5. Colorado Natural Hazards Mitigation Council, and

6. The U.S. Committee on the International Decade for Natural Disaster Reduction.

On the CSU campus, faculty from the Colleges of Natural Resources and Engineering, as well as colleagues in Environmental Health, have expressed interest in the LACSTC. The scope of the LACSTC at CSU revolves around the interest and commitment of colleagues on campus and their established and growing professional interrelationships with colleagues in Latin America.

At the present time there are several proposed models for the LACSTC on campus and for presenting the strengths of Colorado State University. A proposed model includes faculty fellows at the CSU campus and associated faculty fellows at participating institutions and organizations, especially colleagues in Latin America. The proposed model includes ideas for cooperative opportunities between CSU faculty and graduate students with faculty and graduate students at participating Latin American institutions in research, education, and training. As the concept of the LACSTC continues to evolve, colleagues and interested parties are encouraged to participate in the formation of the center's goals, objectives, and strategies for cooperative research, education, and training. The formalization of the LACSTC will provide a mechanism for inter institutional cooperation with colleagues at partner institutions and organizations Latin America.

The Latin American Center for Science and Technology Cooperation (LACSTC) Purpose, Goals, and Cooperating Parties

The LACSTC is a joint cooperative venture between faculty at Colorado State University, specifically the Departments of Earth Resources and Civil Engineering in the Colleges of Natural Resources and Engineering, and colleagues at universities, centers, institutes, governmental entities, non-governmental organizations, and other institutions in Latin America.

The LACSTC provides an organizational structure for joint research, education, and training in science and engineering between faculty and other professionals, along with graduate students, for the advancement of knowledge and application of sustainable management of natural resources. Fields of expertise of cooperating parties include geosciences, forest sciences, marine sciences, ecology, natural resource conservation, natural resource management, recreation resources management, natural hazard mitigation, water resources engineering, environmental engineering, structural engineering, environmental policy analysis, and remote sensing/geographic information systems.

Specifically, the LACSTC focuses on basic and applied research, education, and training in the areas of resource management, natural hazard mitigation, and specific economic development sectors like ecotourism. Initially, goals of LACSTC include: 1.) identification of opportunities for cooperating institutions to enhance their educational programs with new initiatives in environmental education; 2.) joint development and exchange of curriculum and training between the participating universities and organizations; and 3.) joint development of basic and applied research proposals on environmental issues to be submitted for funding to foundations and international agencies.

In working toward the interrelated environmental and societal goals of sustainable resource management, the cooperating parties of the LACSTC are committed to working together along with people, their governments, and other organizations throughout the western hemisphere on the understanding and management of natural and human resources.

Submitted by:

Co-Chairs : Sherry Oaks/Jorge Ramirez
Co-Reporters: Sherry Oaks/Jorge Ramirez

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For More Information Please Contact:

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WORKSHOP ON "MINORITY ISSUES IN WATER RESOURCES AND ENVIRONMENTAL EDUCATION"

Co-Chairs: Sunnie Aburime/Omnia El-Hakim
Reporters: Bradford S. Price/Kristan Cockerill-Kafka

The workshop was conducted by focusing on the list of suggested twelve questions for this topic identified in the Guidelines Section of the Conference Proceedings. The questions were considered one at a time, and each workshop participant was given an opportunity to respond to the question. Responses to these questions follow:

1. What are the unique opportunities and challenges for Historically Black Colleges and Universities?

a. Opportunities

1. Research collaboration with each other and majority schools.
2. Increase funding for research at HBCUs
3. Increase educational level
4. Develop underrepresented groups in the mainstream of society
5. Become involved in environmental clean-up
6. Develop leadership skills of students through curriculum
7. Funding from AID and other agencies for Ph.D.s for minorities and women. Equate HBCUs and MIs as foreign countries.

b. Challenges

1. Develop consortium to seek increased funding from federal sources
2. Develop quality students
3. Inform high school students of HBCU and MI existence through press releases, open houses, outreach to business
4. Increase the number of Ph.D. Black Americans
5. Bring faculty up to state of the art in their discipline

2. How can networks be formed? What can they do?

How:

a. This conference is a good start...must maintain momentum
b. Faculty exchange program, faculty interaction
   - includes formal, semester type teaching exchanges
   - includes informal, short-term, 1-2 week visits and meetings
   - both need money to fund travel and expenses

c. Form horizontally linkages between universities and vertical linkages with agencies (especially those found on campus) - need both
d. Consortia is good way to network internally, is large entity, smaller arrangements between 2-3 schools (min. & maj.) is better for external networking, especially for submitting proposals
e. Must include local schools and industry, and must include political element

What:
a. Among institutions must recognize what the institution is good at, and what they are not good at, then share this information with other institutions!
b. Don't necessarily need to do it all...use incubator and tiger team approach to develop successful proposals
c. Can share resources and info...money is not always the answer, things can be done with limited funding by working together. e.g. IRIS lists funding available...donations of equipment

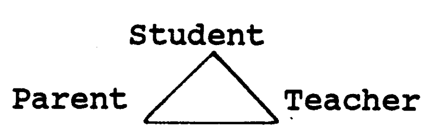
Issues:
a. Money
b. Maintaining momentum of consortium even beyond federally funded years. Failure is management failure
c. Need communications - electronic, satellite, etc.
d. Still trying to figure out how to get together

4. What are the opportunities to work in international development?

a. Already involved to some extent. Strengthen it.
b. Increase relationships with majority universities to develop joint proposals that involve faculty from both schools
c. Foreign countries request increased involvement of HBCUs/MIs in research sponsored by AID, etc.

5. How can universities help more with K-12 problems, and with socio-economic problems in general?

- Develop relationships with high school counselors
- Work with schools for two direction approach:
  K-12 students coming to universities,
  University professors and students going out to K-12
- is essential for K-12 kids to see labs, actual work, students, etc.
- Need three prong approach



- Poorly trained K-12 teachers are a leading discouragement, therefore, need to help train these teachers on their own turf
- High school students are not receiving adequate instruction
- Money is still an issue
    - NSF provides fund for these types of programs
    - Need to include outreach monies in proposals submitted
    - Can start small by identifying dedicated, qualified people to get something going
    - Need communication to exchange ideas, to get information out in a multi-media format - takes money
- Still issue of providing remedial support to freshman & sophomores as well
- Must not only <u>get</u> good students, must graduate good students

9. What is the best way of managing the Consortium

    a. Board of Directors - Representatives from each school, elect chair, chair rotates
    b. Management Office - Executive Director and staff to manage day to day operations. Concerned with cost management, time management and political management

11. How many should collaborate in the Consortium as members; Is there an optimum size of the Consortium?

    a. Currently 117± total HBCUs/MIs
    b. Identify number with water resources elements/programs
    c. Based on level of cooperation could have 20±
    d. Develop criteria for inclusion in group

SESSION 1 PLENARY

KEYNOTE ADDRESSES

MAJOR ISSUES IN WATER RESOURCES FOR THE 90'S

Evan Vlachos[1]

The tremendous increases in the use of water by agriculture and industry, as well as the pressures from rapidly expanding populations, all indicate a growing concern for global water shortages in the near future. At the same time, increased concern all over the world has to do with how to return water to the source and also guarantee that such a return is not spoiled by waste, soil runoffs and thermal discharges.

There is no need to repeat the ubiquity of water and its centrality in the evolution of human civilization. To sum the obvious: water is fundamental to all life form, affecting all ecosystems, it is spatially and seasonably unevenly distributed, and the various uses to which water is put often compete, both quantitatively and qualitatively, with one another.

As one looks back at the last 20 years and the transitions necessary for the 1990s one is also struck by the increasing emphasis on the variety of environmental challenges, the search for sustainable development, the promotion of integrated planning and management, and the attempt to combine structural and non-structural solutions to persistent water resources problems.

If we were to summarize four broad areas of on-going transformations in water resources, we should emphasize: a) <u>conceptual breakthroughs</u>, including shifting paradigms in terms of complexity, uncertainty, turbulence and interdependence of surrounding environments; b) <u>methodological advances</u>, especially multi-purpose/multi-objective approaches, Decision Support Systems, Risk Analysis, and the implications of rapidly expanding computational prowess; c) <u>organizational mobilization</u>, in terms of new administrative mechanisms, institutional arrangements, renewed interest on river basin interdependencies, contingency planning, Alternative Dispute Resolutions, etc.; and d) <u>substantive concerns</u>, signifying the entire gamut of on-going and future quantity and quality problems, new areas of concern, shifting priorities, potential intervention mechanisms, etc.

It is to the last that we must concentrate attention as a variety of crises focus attention to different aspects of water resources in the 1990s and beyond. These crises include potential climatic shifts (e.g., water supply, rising sea level),

[1]Professor of Sociology and Civil Engineering, Colorado State University

megaruptures (including dam safety and toxic spills), socio-political changes (with attendant institutional challenges, alternative management schemes, etc.), transboundary dependencies (and the comprehensiveness of planning and management beyond traditional political boundaries), and the overall consequences from the fast pace of technological developments.

The problematique to be discussed, then, emanates from cross-cutting concerns having to do with the release of water for new demands; the maintenance of agricultural productivity; the minimization of water quality degradation; expanding economics dependent on water; the lack of appropriate institutional and legal infrastructures; and education, training, public information and the transfer of knowledge.

Following such general premises the major issues to be discussed include: a) global climatic changes, b) infrastructure maintenance; c) planning for extreme hydrologic events; d) groundwater protection; e) bays, estuaries and wetlands; f) dam safety; g) the future of irrigated agriculture; h) water supply and wastewater; and i) enhancement of water-related recreation.

The above are but only one indicative list of interrelated issues having to do with the management of water resources for sustainable development. Such critical issues and management schemes imply environmental instrumental values, stewardship ideology, intergenerational equity and appropriate technology commitment. In essence a transformation in paradigms from that of unlimited resources (frontier economy) to one of finite resources and of environmental accounting (sustainable development). In this context water resources management requires continuous coordination between such conflicting and complimentary purposes as: resource planning for substantial economic output; regional planning for successful human habitat; facility planning for technical efficiency; ecological planning for biotic fitness; and, social planning for community integration.

MAJOR ISSUES IN ENVIRONMENT FOR THE 90'S

J. Eleonora Sabadell*

For more than twenty years now the United States and many other countries have recognized that our use of the environment has been and continue to be far from benign and that the environmental problems are still mounting. Past and ongoing misuse of natural resources, uncontrolled releases of contaminants into air, soil and water, and unsound disposal of toxic and non-toxic wastes are some of the practices that have created serious damage to local, regional and global environment.

The continuous decline of the quality of human life and of the ecological systems in many areas of the world has been the critical concern of a myriad of researchers, experts, politicians, managers and the general public. During the last two decades much activity has taken place for the identification, evaluation and mitigation of environmental risks, and laws and regulations for the protection of the environment have been developed and implemented in the United States and elsewhere. The mixed success of these measures, often at great costs, bespeaks of the magnitude and intractability of many of our environmental problems.

Additionally, in recent years the discovery of the ozone layer depletion and the possibility of a change in global climate, both the results of human activities, has generated strong public attention. All these environmental problems have been the object of a great number of international and domestic reports, conferences, programs and projects, with the latest major assembly taking place in mid June 1992, the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, twenty years after thc first international conference on the environment in Stokholm, Sweden.

Which are the environmental issues for the next decade? It is probably safe to say that chemical contamination will continue for the foreseeable future in air, water and soils at decreasing levels from today's because of retrofitting and redesigning of production processes.

Some gains will be made in energy conservation in developed countries resulting in some reduction in CO2 and other greenhouse gases emissions. Future energy consumption in developing countries is a matter of debate and many of the scenarios proposed present great variations in their outlooks. The level of greenhouse gases emission will continue to increase in the near future. Changes in global climate may have secondary effects such as changes in the pattern, frequency, intensity and location of precipitation and wind which, in turn, could substantially alter the environmental conditions of large geographical areas.

* National Science Foundation, Washington, D.C.

The possibility of biological contamination, especially from genetic engineering and other bioengineering activities, will grow if these industries are not regulated substantially. Toxic and non-toxic waste disposal will continue to be a very serious problem especially for industrialized countries. Recycling will have to be subsidized for some time before it may become profitable.

Underlying these problems and in developed and developing countries alike, we still find that the limited and uneven distribution of knowledge and education is one of the main causes of environmental decay. The vicious cycle of poverty, uncontrolled population growth, inappropriate land uses, exploitation of resources, unsafe technologies, and proliferation of hazardous sites, are some of the results of these failings and nowhere the environmental problems are more evident than in many of the rapidly growing cities of the world.

The processes of transferring environmental knowledge and of educating about environmental matters has not been effective in both, developing and developed countries, and from developed to developing nations. Much of what is already known could be disseminated effectively to all whom could benefit from it if these efforts would be given the priority they deserve.

Agendas for environmentally sustainable economic growth have been developed and the call for compacts, agreements, treaties, and other regional and international arrangements have been proposed by a number of governmental and non-governmental organizations at the Earth summit and elsewhere. It should be noted that there is general agreement on the fact that implementing any of these actions will be extremely difficult, and that it will take strong political will, innovative economic approaches, leadership from developed and developing countries alike for resolving their own domestic issues and the settlement of transboundary conflicts to achieve some success.

Advances in safe technologies, non-regret policies, sustainable development approaches, if and when adopted, will help in bringing under control further environmental deterioration, in diminishing future risks and mitigating existing problems. Nonetheless, decision-makers will have to recognize the importance of the human dimension, along with the chemical and physical origins, of pollution generation if we are to succeed in reclaiming the quality of our planet.

Note: The views expressed in this paper are those of the author and do not reflect the official policy of NSF.

National Priorities:
A Vision for Education in Water Resources and Environment

By Neil S. Grigg[1]

Water resources and environmental management are two of the major resource issues facing the planet. Education may be the top social policy issue in the US, along with meeting the needs of an increasingly diverse population. Building human capital is necessary to build economies and societies. The subject of this paper is: how can our educational system focus on these joint problems of environment, education, and diversity?

In this paper, education is taken in a broad sense to include knowledge generation and transfer. In that sense, it includes the three missions, education, research and outreach. It also includes different levels of each of these, for example, formal education will include K-12 right on through graduate training. Education also includes public non-formal education, vocational training, and continuing education for professionals. Finally, it looks broadly at providers of education, including formal and informal educational systems. Figure 1 presents a simple model of this educational system.

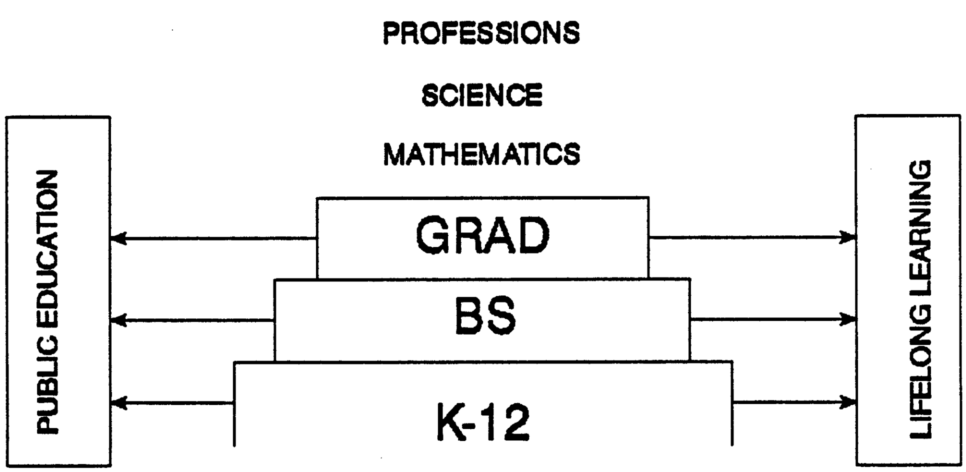


Figure 1. A Model of the Educational System

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Environmental crisis. If any one thing can be said about the environmental crisis since its "birth" at Earth Day 1970, it is that it has intensified and diversified. Certainly educational programs is a necessary key to overcoming this crisis.

The intensification is due both to actual problems and to public perception of problems. Actual problems include population growth, industrialization and the release of increasingly exotic wastes, such as wastes that result from nuclear energy, biotechnology and microelectronics industries. Categories of environmental issues include water problems, air quality, land use management and a group of overarching issues such as public health, managing the indoor environment, toxic substances, hazardous wastes management, preserving biodiversity, energy management and nuclear safety.

Public perception is due both to sophistication of public relations efforts of environmental groups and to the gradually increasing awareness of ordinary citizens about real environmental issues that affect their health, pocketbook and quality of life.

Of course, the purpose of education for water and environmental management, as distinguished from general education, is to prepare professionals and other workers for the industries that have responsibility to manage water and the environment. Public and private sector organizations will be involved, to include federal, state and local government, manufacturers, consultants and research organizations, public interest organizations, universities and educational organizations.

Table 1 shows categories of environmental issues and the industries and organizations with management responsibilities. The table shows the breadth and diversity of the industries and issues that our educational efforts should aim at.

Environmental issues receive different priority in different countries and cultures. In the former Soviet Union and Eastern Europe, environmental problems have reached the nightmare stage. In the Third World, an indication of the concern about environmental issues is the priority given to them by investment banks such as the World Bank and the smaller cousins for Latin America, Asia and Africa.

Table 1. Environmental Issues and Organizations

ENVIRONMENTAL ISSUES INVOLVED	ORGANIZATIONS
<u>Water Issues</u>	<u>Public Sector Organizations</u>
water resources management	federal agencies
safe drinking water	state agencies
poison runoff control	local agencies
wastewater management	public utilities
drought water management	research organizations
ocean and coastal water management	public schools
recreational water management	universities
irrigation and drainage	
flood and stormwater management	
industrial water supply	<u>Private Sector Organizations</u>
aquatic habitat management	
	manufacturers
<u>Air and Climate Management</u>	consultants
	suppliers
air quality control	publishers/press
industrial emissions technology	public interest organizations
climate/atmosphere research	
<u>Land Use Management</u>	
land use control and planning	
soil erosion	
deforestation	
endangered plants	
wildlife management	
sustainable agriculture	
forestry	
desertification control	
<u>Other Issues</u>	
public health management	
indoor environment	
toxic substances	
hazardous wastes	
endangered species	
energy management	
population control	
nuclear safety	

Often when Third World environmental issues are discussed, the issues of poverty in the South and consumption in the North arise. These will be centerpieces, for example, at the UN Conference on Environment and Development (UNCED), to be held in Rio in June 1992 (Business Week, May 11, 1992, and Time, June 1, 1992). At UNCED, the bill for environmental cleanup will be quoted in the range of $125 billion per year by the year 2000. This is called Agenda 21, the proposed action plan to be considered by UNCED.

Environmental issues may cause increasing conflict rather than be solved by concerted action and cooperation, like at UNCED. While environmental issues are receiving more attention and have gained higher priority with business and government leaders, it is not clear that solutions are in sight. The Wall Street Journal mused about this recently: "...the environment may become the hottest issue of the '90's, superseding political or cultural differences as a source of international tension ... Americans of all persuasions should commit themselves to making the world a better place when the millennium ends. A safe ecological environment may have as much strategic importance in 2000 as a stable political environment does in 1990" (Wall Street Journal, January 1, 1990).

<u>Educational crisis</u>. If there's any subject that has received more recent attention in the US than the environment, it is education. The discussion has been complex, with K-12 levels receiving most attention, mostly because they are linked to social and economic issues. The subject of education has so many components that we need a model to locate which part of the issue we are discussing.

While our focus at this conference is at the university level, it involves all of the categories shown in Figure 1. We are primarily interested in students with aptitudes for science and mathematics, although other skills, primarily management and communication, are also necessary. In the formal education pipeline, students will exhibit interests in science and math early on, and as they progress through the pipeline, they become progressively more specific in their paths. For example, environmental engineers at the graduate level will have cast their vote for chemistry, biology and engineering. A hydraulics engineer will have cast a vote for fluid mechanics and related subjects, etc. Today, with the half life of formal education being short, lifelong learning is quite important. It includes continuing education for all skill categories. The other main category is public education. It is necessary that the public have an appreciation for the complexity, conflict and correct value choices in water and environmental management.

Although most of the national education policy attention has focused on K-12, universities are going through an identity crisis. Time's recent cover story described it as "The College Crunch: strapped for money, educators are reinventing the university for the 21st century" (Time, April 13, 1992). "By the year 2000, American colleges and universities will be lean and mean, service oriented and science-minded, multicultural and increasingly diverse - if they intend to survive their fiscal agony."

In a perceptive analysis, J. Wade Gilley presented the challenges as driven by a new economic age, a science-driven economy, changing mores and families, changing demographics driven by aging, diversity, and economic disparities, and shifting economic centers and urban organization paradigms. He reported the main issues from a survey of college presidents as: minority participation in higher education, financing higher education and making it affordable, replacing qualified faculty, helping the US keep its competitive edge, making governance and leadership work and improving the public schools (Gilley, 1991).

Categories of proposed solutions to the K-12 education crisis have been summarized by John Akers, CEO of IBM and chairman of the Business roundtable task force on education: "National assessments, accountability, choice, parental responsibility, local control, and support for preschool children are key to rejuvenated resurgent American educational system. We must go beyond tinkering to fundamental, far-reaching reforms, or see the leading industries, jobs, products and technologies of tomorrow - the engines of America's future - fall into the hands of those faster, better-educated and tougher-minded than ourselves... This is my conclusion after accepting the President's challenge to direct a drive by America's largest corporations to help restore excellence in the K-12 schools" (Akers, 1991).

Comparing Akers and Gilley's analyses, it is apparent that social and economic trends will drive change in our school systems. The new economic and political organization paradigms and the changing population mixes will place demands on both K-12 and higher education. We can look at these demands for signals as to how we can identify opportunities.

The focus on a competitive edge and science-driven economy will intensify the need for environmental education, as well as provide workplace opportunities for graduates. Changing population mixes and increasing diversity signals us to be sensitive to how we can respond to the changes. These, and other socioeconomic issues, create the background for our attention.

The higher education issues that relate to our opportunities are leading and financing higher education, replacing qualified faculty and helping the public schools. We can give attention to the general issue areas identified by Akers, assessment, choice, local control and support for preschool children, but I suggest that our focused mission, interpreted within the larger context of educational issues, should boil down to six main goals:

- Link with K-12: working with the public schools to prepare kids for careers in science and engineering, with an environmental focus;

- Student support: providing support and encouragement to assure the success and quality of graduates in BS, MS and PhD programs;

- Faculty development: developing and equipping faculty in environmental science and engineering for all institutions, with attention to needs of HBCU/Mis;

- Curriculum: developing and enriching effective methods and means to disseminate and transfer environmental knowledge;

- Research: providing the knowledge base to solve environmental problems;

- Dissemination: monitoring the transfer of knowledge to assure that our institutions and the public have the knowledge needed for informed solutions to environmental problems.

Educational system providers must work together to pursue these goals. These providers are K-12, community colleges, four year colleges, universities, graduate/research institutions, continuing education groups, including the private sector, outreach organizations, interest groups and miscellaneous private sector organizations. In addition to the environmental industry groups have vital stakes in the outcomes. These include: water and environmental management organizations and regulators, education agencies, environmental groups and public interest organizations, professional societies and trade groups, water users, industries, chambers of commerce and economic development agencies, the military and the publishing industry.

Specific issues. The issues and questions that fall within the framework of the five goals stated earlier are broad. In this section I list a few of them, and expect that at the conference workshops more will be identified.

Link with K-12

How does higher education work with K-12 more effectively? What are the needs of K-12 to do a better job? Some possibilities include teacher training, field experiences, student programs and other enrichment activities, and scholarships. Under the school choice category, some universities, as in Boston, have proposed to take over the management of public schools. Rather than this, are there some partnerships that can work?

Student support

Students need support in a variety of ways, financial, mentoring, administrative, and academic. Today, students come from a variety of backgrounds, non-traditional ages, minority populations, other fields, etc. How can we respond best to their needs?

Faculty development

We need to replace qualified faculty, and to provide faculty for the minority institutions. Also, there is a need to provide continuing education and support mechanisms for the faculty members who are in service. How can these faculty resources best be provided?

Curriculum

There are many curriculum issues to deal with, for example, hydrology education. One of the issues is the future of the hydrologic sciences (NRC, 1991). Educational issues diverge between the engineering and science approaches to hydrology. The framers of the NRC report compare this to the difference between chemistry and chemical engineering. The report recommends that hydrology must "escape mere inclusion as an option under engineering, geology, or natural resources programs".

Another example is environmental engineering education where the subject matter is broader and more complex than hydrology. At the Sixth Conference on Environmental Engineering Education, held in Corvallis in August 1991, a number of issues were studied (AEEP, 1991). They saw that the profession has the choice to stay with present water focused programs, or to expand to meet society's needs, presumably hazardous waste. They recognized that graduates of present undergraduate engineering programs were not prepared to enter graduate training in environmental engineering. They saw possibilities to introduce new depth and variety at both BS and graduate levels. They affirmed their belief that the MS should remain the entry level degree for work in environmental engineering, and they resolved that there should be a greater presence of environmental engineering at the BS level.

There are many other curriculum issues to deal with. They can be organized by problems, by disciplines, by level, by provider and by industry.

Research

One of the primary questions about research is whether there is sufficient support for it. Research budgets have been cut in federal agencies, and it is difficult to gain support for faculty and graduate student support. How can this be remedied?

Dissemination

Public education and outreach programs is a diverse category that includes both continuing education and training, and public education. I have not focused on it in this paper, but anticipate a productive workshop at the conference. Issues and solutions need to be identified.

Conclusions.

Water resources and environmental management are two of the major resource issues facing the planet and require formal and informal education programs for solution.

After analyzing issues, I have concluded that six issues should receive attention at this conference: links between higher education and K-12, student support programs, faculty development, curriculum, research and dissemination of knowledge. The workshops should identify issues and solutions in each of these areas.

Additional strategic questions include: can consortia contribute to achieving the goals we have identified; are coordinated national strategies in environmental education needed; what kind of international linkages will promote our goals; what is the need for focused centers for research and outreach; how can the needed programs be financed; and how can higher education and K-12 work better with the private sector?

For a personal vision of what we can achieve by working together on these problems, I put forward the following ideas:

1. We should work together to formulate better visions of the needed curricula in water and environmental fields, making sure that they respond to society's broad needs;

2. We should work on the problems of making higher education affordable by forming consortia and teaming up to use technologies and cooperation to increase our productivity and increase opportunities for students, faculty and institutions;

3. Higher education and management agencies and institutions should team up to plan and deliver the needed programs of education, research and outreach/training;

4. We should always be looking for ways to increase opportunities for students in the water and environmental fields, helping them to finance and enrich their educations;

5. We should focus on diversity goals, not just for the isolated purpose of changing the distribution of the faculty or student positions, but to find ways to respond genuinely to the realities of the changing population and to cultural differences in water and environmental management.

I believe that through the programs we will discuss at the conference, we have an excellent opportunity to work together to develop coordinated and joint solutions to problems of environmental management, education and diversity.

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SESSION II PLENARY

MAJOR ISSUE PAPERS

Issues in Water Resources Education

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INTRODUCTION

Water resources is an applied multidisciplinary field with input from engineering (agricultural, civil, environmental, geological, and mining), natural sciences (biology, chemistry, computer science, geography, geology, hydrology, mathematics, meteorology, physics, and statistics), and social sciences (economics, law, political science, and public administration).

Graduate educational programs in water resources exist at over 100 universities in the United States. However, the **water resources** descriptor didn't emerge until the early 1960's when federal legislation was enacted to promote broader-based research related to water problems.

This paper provides a brief historical perspective on the evolution of water resources education. Then, some issues as seen through the eyes of the author are presented.

EVALUATION OF EDUCATION IN WATER RESOURCES

Systems Approach in the 1960's

During the late 1950's, a major water resources program was developed at Harvard University (Maass et al., 1962). This group consisted of Harvard faculty from several areas of the university along with high-level scientists and engineers from the federal water agencies. This multi-disciplinary group evaluated the potential advantages of using a variety of computer-based simulation and optimization models for evaluating water resources problems. Their optimistic conclusions regarding the potential value of computers in water resources led to the formation of systems analysis programs at numerous universities, e.g., Northwestern, Cornell, UCLA, Johns Hopkins. In addition to computer-based methods, the Harvard program stimulated strong interdisciplinary links between engineering and the social and behavioral sciences. These systems analysis approaches are now an integral part of water resources education (Loucks, Stedinger, and Haith, 1981).

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The Environmental Movement of the early 1970's

The strong environmental movement of the early 1970's prompted further shifts in water resources education to provide students with a better background in water quality and ecology. Thus, water resources students now could be expected to have a background in water chemistry and biology with an appreciation of environmental impacts. Associated with this movement was a de-emphasis on the social sciences, particularly economics, since benefit-cost analysis was not a part of the major environmental legislation of the early 1970's.

Hazardous Wastes-Agenda for the 1980's

The water resources field was further modified in the 1980's by very strong new initiatives in characterizing and controlling solid and hazardous wastes. The major impact on educational programs in water resources was providing students with course work and research dealing with the unsaturated and saturated subsurface zones. Interested students also began taking additional course work in geotechnical engineering, hydrogeology, soil physics, and soil chemistry.

Hydrologic Sciences-Focus of the 1990's?

The most significant recent shift in the water resources field is the growing recognition of the need for programs in hydrologic sciences. The catalyst for this awareness was a recent National Academy of Sciences report (Eagleson et al., 1992) which strongly recommended such a program. Their primary argument is that the field of hydrology has been too strongly influenced by applied problems, typically in engineering. Thus, insufficient attention has been devoted to understanding the basic physical, chemical, and biological processes.

CONTEMPORARY ISSUES IN WATER RESOURCES EDUCATION

Water resources education in the 1990's will continue to be driven by its strong applied focus, e.g., global climate change, deforestation, severe pollution problems in eastern Europe. However, the evolution of graduate programs in the hydrologic sciences could have a major influence on future directions in this field. The extent of the impact of the hydrologic sciences is somewhat dependent upon the availability of research funding. The National Science Foundation has recently initiated a modest program in this area.

The above discussion has illustrated how the water resources field has been impacted by a combination of the availability of new methods, e.g., computer science, and a changing set of problems, e.g., groundwater contamination. However, I would like to focus the balance of this paper on how water resources education is apt to be influenced by a new set of external forces emanating from the public's view of the role of universities in society.

The period of time during which the water resources field has grown so rapidly corresponds to an unprecedented growth of universities in general, and programs in science and engineering in particular. As mentioned earlier, over 100 U.S. universities now have graduate programs in water resources. This growth is based on the ability of these programs to have a viable market for their graduates, and the opportunities for their faculties to obtain sponsored research.

Universities are increasingly being challenged to be more "productive" and to devote more of their energies to teaching, especially undergraduate students. Prospective employers of these students expect them to have some background in newer management techniques such as total quality management. The extent to which universities adopt these new methods remains to be seen. If they do, then water resources education will be impacted accordingly since some fundamental changes in attitude are required. For example, the cultural changes listed in Table 1 are essential ingredients.

Table 1. Cultural changes needed to implement Total Quality Management (TQM).

From	To
Bottom line emphasis	Quality first
Meet specification	Continuous improvement
Get product out	Satisfy customer
Focus on product	Focus on process
Inspection oriented	Prevention oriented
Sequential engineering	Simultaneous engineering
Compartmentalized activities	Cooperative team efforts
Focus on models	Focus on databases

Contemporary university education puts a premium on competitive, individual efforts to "solve" problems at the least cost. The educational process partitions the overall problem into numerous subsets. Students learn how to analyze their portion of the problem. They receive input from others and pass the results of their analysis "over the fence" to the next person. How will such changes in attitude and philosophy affect water resources education?

Starting with the technical side of this possible modification in our approach to water resources education, three major improvements are needed in our educational process:

1. Statistical quality control. Fortunately, statistical methods already play an important role in water resources. Thus, it should not be too difficult to add this subject to the curriculum.

2. Metrology. Students need to understand and be able to utilize modern techniques for making measurements and using associated data acquisition systems.

3. Process control. Water resources engineers seldom have any background in control theory. This topic is taught in virtually all other areas of engineering. The material is a companion with items one and two listed above.

The introduction of the above technical subjects should be relatively easy since they have a strong academic content and the faculty would consider them to be rigorous topics.

Of equal, if not greater importance, is for the students to learn the TQM-related philosophy early in their education so that they can use it as part of their educational experience. Unfortunately, the faculty must first accept this philosophy and use it in their courses in order for the students to appreciate it. For example, professors need to provide constant feedback to the students; encourage, if not require the students to work in teams; and perhaps even team teach the course with a colleague. This represents a major change in philosophy for our faculties.

On the productivity side of the problem, we may see a significant contraction in graduate-level education in water resources with a strong shift in emphasis to undergraduate education. Associated with this shift may be a stronger desire to enhance the laboratory and design experience of undergraduates. This will pose a significant challenge for contemporary faculty who tend to specialize in developing computer models and who have little or no laboratory or professional design experience.

CONCLUSIONS

Educational changes in water resources will continue to occur in response to emerging problems as it has during recent memory. We are accustomed to adapting to such changes. However, universities can expect to encounter more substantive challenges in the 1990's due to shrinking budgets and changing attitudes regarding their proper role as providers of educational services. We need to be able to react to both of these internal and external stimuli.

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SESSION III PLENARY

MAJOR ISSUE PAPERS

ISSUES IN WATER RESOURCES AND ENVIRONMENTAL OUTREACH

W. Dennis Lamm, Ph.D.[1]

Cooperative Extension in the state of Colorado was established in 1915 as a result of the federal Smith-Lever Act. After more than 75 years of existence, Cooperative Extension at Colorado State University currently has a presence in 58 of the 63 counties. Twenty of the counties, however, have only a single Extension faculty member living in the county. This presents some challenges as we attempt to address the needs of local people in helping them to make informed decisions about a variety of topics. As the third component of a land-grant university, along with resident instruction and research, Cooperative Extension has become the eyes and ears for the people's university. In this role, we tend to have firsthand knowledge and understanding many of the issues facing the people of Colorado.

Until recently, Cooperative Extension primarily focused on assisting production agriculture, helping homemakers with their canning and textile problems, and encouraging 4-Hers with their projects. In the past five years or so, however, at the local, state, and national levels, we have discovered that simply increasing yields or weights in production agriculture, for instance, is not meeting the needs of people. We are being asked to organize our efforts in a more interdisciplinary, holistic approach to problem solving. A rancher, for instance, might be achieving outstanding reproductive performance in his/her cow herd and might be topping the sales with their weanling calves, but still be undergoing foreclosure of his/her operation. We are being asked to take a look at inventorying all the resources available to the operation and then to assemble them in a package that will optimize production and maximize profit. Issues-based programming within the Cooperative Extension System has subsequently emerged to address clientele problems.

Unfortunately for Cooperative Extension nationwide, the identification of issues and the demand by clientele to assist in addressing these issues has arrived simultaneously with the downturn in the national economy. Consequently, there have been considerable cuts in personnel and financial resources that have presented challenges, but also opportunities to Extension. Particularly in the area of water quality, some areas of the country have undergone severe crises in view of contamination of water supplies from various non-point and point sources. Fortunately, here in Colorado we are not in a crisis mode, in my opinion, and we have enacted numerous programs that encourage the voluntary adoption of best management practices by all concerned.

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We have a Pesticide Applicator Training Program that trains chemical applicators in the safe and proper use of pesticides. In performing this task, we have established close working relationships with the Colorado Department of Agriculture and the Environmental Protection Agency.

As water quality issues have unfolded, agriculture is taking the brunt of the criticism for many of the water quality problems that have been identified to date. Therefore, Extension's role in the educational process has changed. Instead of enhancing production, addressing this issue has forced us to consider optimum production that incorporates best management practices to reduce the possibility of groundwater contamination. Another issue incorporated into the water quality issue is naturally-occurring contaminants, such as the salinity problem that occurs in many areas of the state. There is a major investment by the USDA and Department of Interior agencies to address the salt loading of the Colorado River. Due to the multi-state and multi-national nature of this problem, considerable effort has occurred to date and will most likely continue into the future. Unfortunately, northeastern and southeastern Colorado river systems both have high levels of salinity, yet money to address these sites has not been forthcoming to date.

Hence, one of the challenges for Cooperative Extension is to identify and address the needs of people, although politics sometimes interferes with accomplishing the task at hand. Our role with production agriculture has changed somewhat since we do work closely with some of our sister agencies who are in a more regulatory role. We have attempted to maintain our delivery of unbiased, research-based information and have strongly avoided the role of regulator. We do not have a product to sell, nor do we have dollars available for implementing practices on a cost-share basis.

The other major effort in the water arena with which Cooperative Extension is confronted is the issue of water quantity. Cooperative Extension was instrumental in implementing the evapotransporation system for lawn watering in the Denver metro area and has continued efforts toward achieving efficient water management. We currently support most of the modern irrigation technologies to utilize more efficiently this precious natural resource. As a side benefit to improving irrigation practices, we often have a significant positive impact on water quality. There is apprehension, however, that Cooperative Extension, by saving water from agriculture, is simply freeing up this water for use by urban dwellers. Consequently, there is some reluctance on the part of production agriculture to implement best water management practices.

As we have embarked on playing a more meaningful role in environmental outreach and environmental education, we have provided instruction for school children and teachers with summer camps and workshops. We have had to network and connect with many other agencies that are involved in similar types of endeavors. We simply do not have the resources to fully conduct these programs independent of others. In the agricultural sector, however, there is resistance and possibly resentment to the use of "environment" in the conduct of our programs. The agricultural community is feeling regulated beyond reason and resents agencies telling them what they can and cannot do. Consequently, Extension has the responsibility to inform this constituency without necessarily being perceived as being "environmentalists." We in Cooperative Extension, however, feel an obligation to inform all of our publics about the issues and to also listen to their viewpoints.

It appears agriculture, in particular, is being scrutinized and there are certain elements of our society who would certainly wish to set the agenda for how we produce food and fiber in this country. Our approach and our challenge is for all of us to be good stewards of our natural resources, while at the same time to produce these basic necessities with a vision for the future. Unfortunately, some of the groups that are based on single issues often do not have a vision for the future. This puts many of our constituencies in a defensive mode and makes education in a rational setting somewhat idealistic. Many of the emotional issues that we are attempting to address cannot be solved solely by science.

In the past six to eight years, many organizations, commodity groups, and even regulatory agencies have identified an educational role as part of their mission. This presents a challenge for Cooperative Extension in performing our mission as a part of the land-grant university. Fortunately, we have good rapport with most of these groups and attempt to avoid duplication of efforts. As mentioned previously, Cooperative Extension simply cannot be the sole supplier of information for every issue that arises. However, due to our linkage throughout the state and nation in more than 3,500 Extension offices, we are able to network and connect with other groups who collectively can provide the answers people need.

In summary, my perception is that Cooperative Extension is most likely aware of and probably involved in some capacity with most all issues that will be identified at this conference. Our role has changed over the years from being the sole supplier of unbiased, research-based information to now becoming a broker, networker, facilitator, coordinator of this information data base to solve people's problems. At times Cooperative Extension is criticized for simply being the messenger or perhaps the bearer of unwelcome information. However, it is our role to remain objective, credible and to assist in establishing a vision for good stewardship of our natural resource base.

SESSION IV PLENARY

EDUCATION IN WATER RESOURCES

EDUCATION FOR SOLUTION OF FORTHCOMING WATER RESOURCES PROBLEMS

by

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ABSTRACT. Continual change and advancement in science, technology, human needs, society's attitudes, demands and information require adjustment in education of water resources professionals. Selected nine topics of likely future water resources problems and solutions demonstrate the need for improved education. Pollution and protection of water environment have created controversies of significant influence on development. Demands for decrease and control of pollution has transformed planning and operation of water resources systems. River runoff is attractive for monitoring the potential climatic change. Water resources development partially counteracts the negative aspects of climatic change. Aging of water structures and systems poses new technologic and economic challenge. Pressures to extract the maximum benefit from existing water resources systems require well educated and experienced specialists. Modern societies do not tolerate high risks, so the risk assessment, optimization and abating have been put on social and economic agenda in many countries. With time, increased clashes develop between proponents and opponents of water resources projects. Reallocation of water rights needs efficient solutions. Because of versatile and increased trends in pollution worldwide, strategies for procurement of drinking water should adjust to new conditions. Resulting diversities and complexities in solution of future water resources problems, issues and needs should lead to substantial modification in educational programs for water resources professionals.

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CLASSICAL EDUCATION AND SELECTION OF PROFESSIONALS

Education of professionals for water resources is based on a fundamental principle, namely to oriente the involved professionals to become either specialists or generalists. Because of the ever-increasing diversity and complexity of water resources systems, issues and controversies, problems and solutions, this principle will likely be applied in a much more pronounced manner in the future than. Specialists will come from a variety of scientific and technologic disciplines, with hydraulic and environmental engineering continuing to stay in the center of needed specialization. Generalists will come from any discipline which is related to planning and operation of water resources projects.

Leaders in water resources planning and operation are most often the self-educated generalists. In industrial countries, they usually evolved from any specialization related to water resources, if an individual had leadership qualities. Help may be an additional degree in management, economics, business or administration.. Versatile experience in a variety of water resources systems and problem solutions usually helped.

SOCIETY'S ATTITUDES AND DEMANDS

Societies change in their attitudes and demands. Education of water resources professionals should be adjusted to this change. Adjustment in educational curricula to needed profiles of professionals by development of new programs and courses should always precede the projected need for new types of specialists and generalists. Because education for solution of forthcoming water resources problems must precede the time solutions have to be implemented, projecting future problems for a couple of decades in advance represents a high responsibility of decision makers in water resources.

Because of population growth and the general pressure for increase of standard of living, at least for the lowest social strata, development of natural resources and the land is an unavoidable requirement. Similarly, it is imperative for asociety to protect its environment. These two concepts, development and protection of, when implemented in full inevitably lead to controversial issues and problems which require the most enlightened solutions. Society now demands more a more a cooperative relationship between development and protection, rather then confrontations which result in costly delays and losses.

TRENDS IN WATER RESOURCES PROBLEMS AND EDUCATION

Conflict Resolutions in Water Resources

Water resources development implies change in nature. Problems solution require structures for water transfer in space, its transfer in time, change in water energy potential and modification of water quality. A developmental change in nature is also an environmental change. Most changes may be conceived as undesirable impacts on nature, to be eventually opposed. Opposition has progressed to the point that many water resources projects of sound economic and environmental solution are routinely opposed. As a consequence, projects are delayed or abandoned. To resolve these controversies, which occur now all around the world, the well educated professionals, both as specialists and as generalists, are needed. To accomplish this task, education must be tailored to solution of new water resources problems.

To resolve controversial issues in water resources development most economically and efficiently, The future education of professionals should include two special programs (either as the formal course work or as the continuing education): 1. Identification and analysis of contentious issues between water resources development and protection of environment; and 2. Scientifically based resolution of conflicts in water resources.

Pollution and Environment

Consumer pays the cost of extraction of raw materials for production of goods and delivery of services. Consumer is not forced to also pay the cost of harmful disposal into the environment of remnants of manufactured goods and their use, or of services rendered. They are simply dumped into the air, water, soil, rock, land, biomass. With time, controversies arose between development of natural resources, especially water resources, and the movement to protect environment. Ever since 1950's, protagonists of development had to cope with resistance of opponents to many consequences of development, specifically as pollution in the environment.

Many rivers and estuaries have become large sewers. Aquifers and lakes are polluted. Groundwater adjacent to river is affected by regular exchange of water with the polluted river. Karstic limestone systems are often significantly polluted. All these low quality waters and water environments require cleaning. It is more difficult to clean polluted grains of silt, sand and gravel, or rock fissures, bottom and sides of underground channels and caves, and bottom sediments of rivers, lakes and reservoirs than to remove polluted water. Pollution of water environments by agricultural chemicals and industrial untreated waste water and gas are the major threat to health and quality of aquatic and general life. The emerging "water quality hydrology", as new hydrologic discipline which investigates water quality processes in nature, including influence by humans, should become a compulsory course in education of almost any water resources professional.

Environmental water quality problems and solutions have now outpaced in breath and depth of their significance the classical sanitary engineering activities of treating water. Good water quality in nature has become a symbol of healthy environment and a measure of state of the civilization. Education on all the aspects of water quality in nature and their role within the society's infrastructures seems to have become a must for the future water resources professionals. The solution of water quality problems has become one of the most complex multi-disciplinary aspects of comprehensive water resources planning and operation. It requires a highly integrated team work, in which all team specialists should possess a very advanced knowledge on water quality

Change of Climate, Water Resources Development and Protection of Environment

Emissions of gases into atmosphere create problems due to climatic changes (ozone layer distraction, acid rain, carbon based greenhouse warming). According to model forecasters, these changes will impact water resources systems in various ways, mainly that dry regions in the world will become drier and warmer, and that ocean level will be raised due to partial melting of ice caps. While prediction of ozone layer threat and acid rain occurrence seem well documented, prediction of carbon dioxide greenhouse effect is not yet accepted as definitive as forecasted. Water resources planners and operators consider these impacts seriously.

There is no better geophysical variable for controlling the overall climatic change in water than river runoff. It integrates precipitation and evaporation. Therefore, future professionals must be well educated in statistical and mathematical techniques which help accurate discriminations of the change in all geophysical variables which affect water resources and environment in one way or another.

The threat to fertile semiarid regions of the world is via a decrease of agricultural productivity due to less precipitation and more evaporation. This threat may be alleviated in two ways: control of warming up through stabilizing the content of carbon in the air, and massive irrigation in these areas, even by long water diversions. Threat from the rise of ocean level may be fought against by controlling carbon in the air, but partially also by transferring water from oceans to continents through reservoirs, water supply and irrigation. Special reservoirs (in depressions, cold regions, estuaries, tidal power plants), with complex purposes may decrease ocean level. Presently, ocean level is 2-3 centimeters lower due to such activities of the past. In future, that effect may reach 10-15 centimeters. All this potential activity may require additional education and specialization of water resources professionals.

Aging of Water Resources Structures and Systems

These aged structures and systems pose problems for which classical education of specialists and generalists does not provide sufficient knowledge for the most efficient solutions. It seems that a new speciality in water resources engineering is on the making, namely the specialist for renovation of water resources structures and systems. At present, expertize for this renovation is acquired either on site by working or through self-education rather than through special programs, courses or books.

Extraction of Maximal Benefit from Existing Water Resources Systems

Trends to "squeeze out" as much benefit from existing water resources structures and systems are unavoidable. They may require advanced knowledge and accuracy in solution which the ongoing education does not provide. Expectation is that modern information theory, system analysis, operational research, computer technology, forecast technology, expert systems and other innovations may be able to do what classical technologies of planning, design and operation of water resources systems have not be able to do. For this purpose, it is relatively easy to locate the well specialized people.

However, more than anything else, an experienced and knowledgeable generalist may be the most important individual in this task. He can assemble the team of best specialists and guide it to good solutions. With a limited investment, he may lead to the most economical returns, especially in obtaining the much higher returns than with the new systems and structures. A lot of efforts could be justified to educate and produce such generalists.

Estimation, Optimization and Abatement of Risks

The more advanced an economy, the less ready a society is to accept high risk. As water resources projects involve various types of events which carry with them unavoidable risks, pressures continually build up to decrease these risks at the least expense to society. Here, it is impossible to fulfil this request, namely to arrive at a risk-free society. Risk assessment, optimization and abating have become a new speciality which deserves a better position in education of specialists than the case is now. Complexities in assessing risks and diversity in approaches to finding the optimal risk, with its abatement at any stage of economic development, require well educated water resources professionals.

Data and other information, requirements and assumptions change with time. Growth of wealth in risk prone areas affects the risk/cost optimization relation. Risk level should be periodically reassessed and where technically and economically feasible also reduced to a new economically acceptable optimal risk level. The main problem may consist of difficulties to assess, optimize and implement the new risk level. Example is the decrease of flood risks at about 5000 large dams in USA, which likely will demand about 20 billion dollars of new investment. Education in this area of water resources planning, design and operation requires new approach and adjustment of well known risk abatement technology to the specific aspects in water resources, especially how one could best combine various interdependent risks into an overall plant, structure or system risk.

Conflict of Interests in Water Resources Projects

Most water resources projects in the world are in public domain. They are conceived as largeness of the government to be tapped by individuals or groups. Many parties to the conflict of interests are tempted to maximally benefit either from future products of these projects or from maximal possible compensation for damage, property expropriation or inconvenience. Litigation leads to both, delays and social cost of the project. Both lead to a decrease of the benefit-cost ratio. Interested parties may be divided in three groups, those benefiting and willing to pay their share of the cost, those which may suffer from the project and are entitled to a fair compensation, and those wanting to benefit from the project without any contribution. The important step in solution of conflict of interests is to identify clearly these three groups.

Conflict resolution has become a scientific discipline. It can be taught either as a general discipline to be applied anywhere when conflicts arise, or as a discipline applied to particular area of technical and economic specialty. Generalists in water resources, especially the top planners and decision makers, should be well exposed to major principles, procedures and intricacies of conflict resolution.

Reallocation of Water Rights

Water in nature is limited in its availability. In some areas all feasible water for allocation has been already allocated. With time water becomes more valuable to other purposes. Therefore, the concept of reallocation of water rights is borne. Furthermore, the concept of water and water rights becoming the market commodity is also introduced by necessity, instead of all matters of reallocation treated only administratively. These transfers of water rights require the most advanced knowledge of the way how to resolve a variety of related political, economic, technical and legal issues.

In this domain of water resources activities, professionals have yet to develop the standardized complex approaches and methods for an efficient transfer of water rights. The education of professionals, especially of generalists, for the solution of such problems will likely be most attractive either by publishing books on systematic ways of solutions, or by offering the special courses in continuing education.

Evolutionary Change in Water Supply Strategy.

Springs and aquifers represented the best water for drinking purposes in the past. This assumption is no more valid in many industrial societies. Some of these springs and groundwaters already belong to the most polluted sources of water. This fact should change attitude and concepts, as well as education of specialists in water resources and sanitary engineering.

Education of specialists in water supply technology, especially of the best drinking water, must stress not only where water is available as well as in what quality state at present but also what quality they are most likely to be at in the future. Technologies of assessment of present and future interactions between water environments and the general environment , as they slowly evolve, should be the base for this future education. Even the idea of industrially producing different types of excellent drinking waters should be included under the special continuing education via water supply courses.

EDUCATIONAL DILEMMAS IN WATER RESOURCES

The classical education in water resources seems to have left the above nine areas of needed education for the now ongoing and the expected future water resources problems to be mastered by professionals by a trial-and-error method in practice. The work experience, special courses within water resources institutions or consulting firms, the continuing education by special programs or courses at the learning institutions and the self-education, seems to have been used as the ways to solve the above educational problems. The continuing upgrading of the post-graduate courses, however by also eliminating the obsolete technologies from them in turn, may add to solution of educational problems.

CONCLUSIONS

1. Water resources problems change with time because of new information, new concepts and technologies, new needs, which all may require new solutions.

2. Attitudes and demands by society also evolve with time, thus imposing new approaches and solutions to the old and new water resources problems.

3. Professionals in water resources disciplines have become divided by necessity into two major groups, specialists and generalists, with each group needing change in education occasionally, because of evolution in problems, attitudes, demands and technologies.

4. The advent of new complex water resources problems, as the nine selected cases above demonstrated, requires many future changes either in formal or in informal institutional or on-the-spot continuing education of water resources professionals.

THE ROLE OF TRAINING IN INSTITUTIONAL DEVELOPMENT
EGYPT WATER RESEARCH CENTER

M. Abu-Zeid and D. K. Sunada[1]

INTRODUCTION

The United States government is engaged in several large cooperative developmental programs with Egypt. One series of programs is with the Egypt Ministry of Public Works and Water Resources (MPWWR) and these programs are designed to increase the nation's capability to manage its water resources and to increase agricultural production. The U.S. Agency for International Development (USAID) initiated this series of programs in 1976 with the Egypt Water Use and Management Project (EWUP). Based upon the results of EWUP, USAID in 1981, initiated a multi-component project named the Irrigation Management Systems Project (IMS). The purpose of IMS is to strengthen the MPWWR's capability and capacity to plan, design, operate, and maintain the irrigation distribution system. The IMS Project is scheduled to end in September, 1995.

The Consortium for International Development (CID), with Colorado State University (CSU) as the lead managing university, has been the contractor for three USAID projects; Egypt Water Use and Management Project (1976-1984), and two of the components of the IMS, the Irrigation Improvement Project (EIIP 1985-1991) and the Water Research Center Project (WRCP 1988-1994). All three of CID/CSU's projects addressed the need to provide improvements to Egypt's water resource management capabilities and the institutional capabilities to sustain the irrigation and water systems. Thus, in addition to developing new irrigation practices and building new irrigation structures, the projects also enhanced the professional staff's capability to manage the organization that evolved with the incorporation of technical innovations. One critical component to an improved institutional environment is having a well-trained staff.

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[1]Chairman of the Water Research Center, Cairo, Egypt and Professor of Civil Engineering, Colorado State University, respectively.

EWUP's purpose was to improve the social and economic well-being of farmers of small farms. This was accomplished by development and implementation of irrigation water management in conjunction with agronomic practices to increase agricultural production, to develop efficient water use practices and to reduce drainage problems. An additional objective was to strengthen the institutional capacities of the MPWWR and the Ministry of Agriculture to develop and implement improved on-farm water management programs.

EIIP evolved from the findings of EWUP and had two major objectives. The first was to demonstrate practical procedures to remodel irrigation systems so that the methodologies could be applied to improve irrigation systems throughout Egypt. The second was the development of the Water Research Center by improving the research capacity of the Research Institutes and by developing a centralized information data center. The Water Research Center began in 1975 when the MPWWR consolidated its water management research efforts. The Water Research Center is made up of the following eleven research institutes: Coastal Protection, Drainage, Groundwater, Nile, Hydraulics and Sediment, Mechanical and Electrical, Weed Control and Channel Maintenance, Construction, Water Distribution and Irrigation Systems, Water Resources, and Survey. Based upon the findings of the EIIP, the Water Research Center Project (WRCP) was designed to increase the institutional capacity of the Water Research Center and its eleven research institutes to conduct research, to solve Egypt's water resources problems and to provide the basis for establishing water policy in Egypt.

One goal, common to all three projects, was to develop the long term capabilities of the Water Research Center to provide the MPWWR and Egypt with solutions to their irrigation and water resource problems. The training strategies that evolved from these three projects were designed to upgrade the Ministry's capability to solve water resources problems.

TRAINING INPUTS TO INSTITUTIONAL BUILDING

The training programs consisted of long term academic degree programs, short term technical programs, and on-the-job skill development programs. The objectives for the training phase for all of the projects are as follows:

1. Develop technical skills in key staff members through long-term academic, degree oriented training.

2. Update technical and management skills of senior staff members and directors of institutes through non-degree academic training.

3. Develop capabilities of personnel through subject-specific short courses in technical, management and administrative areas.

4. Provide on-the-job training by assisting institute personnel to complete specific tasks and sub-tasks related to on-going research.

Training needs were identified to complete essential activities to achieve various MPWWR goals and objectives and training programs were developed for suitable personnel to attend. The criteria for selection of personnel for various training opportunities included present and future job responsibilities, academic qualifications for academic degree programs, English competency for participants travelling to the U.S., and personal circumstances allowing them to attend a particular program.

The implementation of training consisted of either academic training, short-term technical programs, attendance at conferences, or on-the-job training. Academic degree programs were provided by the three projects. Students and their supervisors in Egypt selected universities and departments based upon their needs and goals. The students from the WRCP were in many areas and were encouraged to attend universities throughout the US.

Tours, field trips, and conferences were part of the training programs to provide opportunities for Ministry personnel to see related projects, and visit laboratories and field research sites in the US. Conferences provided Ministry personnel the chance to obtain state-of-the-art information on critical research and water management issues.

On-the-job training was provided by more than 50 professionals on several temporary duty (TDY) assignments, as well as the long term resident American staff members. By working with specialists on specific activities, the institute personnel were better able to address water resources issues in Egypt.

IMPLEMENTATION OF TRAINING PROGRAMS

Egypt Water Use and Management Project

Twenty-one staff members were provided up to two academic semesters of non-degree academic training at Colorado State University. Because EWUP emphasized the need for interdisciplinary research to solve Egypt's irrigation problems, the academic training was designed to upgrade the professional knowledge of engineers, agronomists, economists, rural sociologists and computer science. Four of these Egyptians continued on to earn their M.Sc. degrees in the United States and two others received their Ph.D. degree in Egypt under other sponsorships.

Short term technical training was provided for 40 Egyptian staff. The training courses were from one to four months in duration and were related to the on-farm water management focus of the project. The programs included water management, soil-water-plant relationships, water control, water measurement, on-farm irrigation techniques, interpersonal relations and communication (for working with farmers), precision land leveling, water scheduling, crop management practices, construction management, and computer-assisted design and record keeping.

A training program was developed with the Salt River Project in Arizona for 46 participants. This program provided hands-on experience for MPWWR professionals in the operation, maintenance, and management of irrigation systems. The Salt River Project also provided professionals who went to Egypt and provided technical guidance in the operation, maintenance, management, and modernization of Egypt's irrigation system. Topics included in this training program are data communication, water measurement and record keeping, water scheduling, water conveyance construction and maintenance, design of irrigation structures, conjunctive use of surface and groundwater, project management, management reporting, and management decision making processes.

An on-the-job training program to introduce Ministry professionals to interdisciplinary on-farm water management research was a field-oriented training program developed by Drs. Clyma and Sunada. This program emphasized improving agricultural production through the diagnostic analysis process with an interdisciplinary team of agronomists, economists, engineers and sociologists. The Ministry of Public Works and Water Resources assumed complete administration of the course within two years of its development and it is now institutionalized in the Ministry and is being conducted on a regular basis. Part of this course was the training tour of irrigated agriculture in the southwestern U.S. The objective of the training tour was to present: (1) state of the art technology, (2) alternative water delivery management systems, (3) on-farm water management advisory service, (4) salinity control and salt tolerant crops, and (5) alternative application systems. To date, a total of 189 Egyptians have taken this training course. This course formed the basis of the two large Water Management Synthesis Projects which presented this course in Sri Lanka, India, Pakistan and other countries.

Egypt Irrigation Improvement Project

Two Egyptian organizations, the Water Research Center and the Regional Irrigation Improvement Project (RIIP) were included in the EIIP. Along with the expansion of the participating institutes came a corresponding expansion of training responsibilities. Training for the RIIP office staff consisted of short term technical programs and on-the-job training. The short term training objective for the RIIP component was to develop the technical capabilities of the RIIP staff to undertake all phases of the work necessary to successfully rehabilitate and improve Egypt's irrigation system. That process includes identifying problems in the system from an interdisciplinary point of view, preparing technical plans and economic assessments for solving the identified problems, selecting the most appropriate alternative, preparing detailed construction plans for improvement work, implementing plans in cooperation with farmer water users associations and the Irrigation Advisory Service, and monitoring and evaluating the performance of the rehabilitation work.

EIIP provided academic training for 32 Water Research Center staff members. The students studied in four disciplines: engineering, fisheries, sociology, and economics and at seven universities. The academic programs included water resource management and development, soil mechanics, hydraulics, consumptive use, soil-water relationships, structure and construction, on-farm water management, drainage, soil physics, aquaculture and fisheries biology, surveying, agricultural economics, and rural sociology. In addition, three individuals worked on post-doctorate studies and three individuals worked on dissertation research topics and obtained their Ph.D. degree from Egyptian universities.

The short term training program for the Water Research Center component of EIIP was designed to increase capabilities in the Water Research Center so that research, research support, administration, and administrative support can be sustained. The subjects covered by the training programs included computer operation, general management techniques, hydraulics, hydrology, structures, irrigation, on-farm water management, soil-water conservation, salinity, groundwater, drainage, agriculture, surveying, fisheries, coastal protection, navigation, and extension sociology.

Water Research Center Project

The WRCP's training is a large investment in the future of Egypt's water resources planning and management. One major objective of this project is to provide a trained cadre of M.Sc. and Ph.D. degree personnel to increase the research capabilities of the Water Research Center. Another objective is to improve the research and management skills of the current staff of the Water Research Center and to disseminate research results that can be readily used by the MPWWR, the nation as a whole and the international community.

The WRCP is scheduled to have 44 participants obtain a M.Sc. degree and 31 participants obtain a Ph.D. degree by the end of 1994. The degree programs are designed to meet specific needs of the Water Research Center in areas such as irrigation, water resources planning, computer science, coastal protection, oceanography, drainage, groundwater, hydraulics, sedimentation, fisheries, construction, soil mechanics, management of large projects, surveying, earth sciences and water quality. The leadership of the WRCP (both in Egypt and at CSU) emphasized diversity in academic training. As a result, a total of 17 universities have been involved in long term training and 10 additional universities and U.S. government organizations have been involved in short term training. One historically black university, Central State University, has provided short term training to students from Egypt.

To ensure that the students' programs met the needs of their respective research institutes, the students maintained contact with their Research Institute Director and in some cases, the Director became a member of the student's academic committee. Where possible, the student's research topic was selected by the student and his academic advisor to be consistent with the goals of the research institute. This coordination ensured that the activities of the students in the U.S. contributed to the output of the research institute in Egypt.

Colorado State University has established a campus in Egypt to provide any regular CSU academic courses taught by CSU faculty. Anyone who is admitted to the Graduate School at CSU and who successfully completes these courses in Egypt is granted formal CSU credit as if they were attending class at CSU. The credits are counted in a normal manner towards an advanced degree. It is possible for a student to take all the course requirements in Egypt and complete much of the research before going to CSU to complete thesis and/or dissertation requirements. The student need only be in residence at CSU for one semester for the M.Sc. and two semesters for the Ph.D. This program reduces the cost of the student's academic program and provides much flexibility in designing the student's program for a degree.

One additional training opportunity offered to Water Research Center participants is attendance at professional conferences. Such conferences provide the means by which state-of-the-art knowledge can be transferred. Since the Water Research Center is a research organization, the staff themselves have presented many technical papers at such conferences. In the last three years, more than 83 papers have been presented at various conferences through out the world by Egyptian researchers and students on the WRCP. These contributions add to the prestige of the Water Research Center and contribute to the institutional capacity for obtaining future projects.

Numerous in-country training programs have been conducted by technical assistance professionals from more than 25 organizations. Training was conducted on various topics such as the use lysimeters, sediment samplers, survey equipment, computer systems, and writing technical papers. These hands-on training programs increase the technical skills of the Egyptian staff and increase the quality of research being conducted by the Water Research Center.

Accomplishments of Trainees

Several of the staff who have participated in the training programs have been successfully integrated into the Water Research Center Research Institutes. They have become project leaders, assumed positions of director and deputy director of research institutes within the MPWWR, and Under Secretaries of State. Several of the trainees have received scholarships and assistantships to pursue additional academic training in the U.S. and several recent graduates have been offered employment in other countries. The knowledge and skills of the trained staff are being shared not only in Egypt but through out the world.

Summary

To summarize, the implementation of the training component of the three projects has provided 363 short term training activities in the U.S. An additional 189 individuals participated in the EWUP on-farm water management training course. Thus far 52 individuals have obtained a M.Sc. degrees and 10 have received their Ph.D. degree in the United States through the three projects. An additional four Egyptians have earned their Ph.D. degree in Egypt. It is anticipated that 31 students will complete their Ph.D. and 19 will complete their M.Sc. degree by 1994.

Conclusions

The technical and management expertise of the staff of the Water Research Center has been significantly strengthened by the training programs provided by the three projects. The objective of the three projects to provide numerous individuals with relevant and necessary training experiences and programs has been accomplished. The human resource base for the Water Research Center has been significantly increased and the staff of the eleven research institutes are now able to better fulfill the research needs of the future.

The MPWWR staff were provided with modern technology and innovative ideas and techniques to help improve the welfare of the people of Egypt. Additionally, the staff in the Water Research Center are sharing their expertise by presenting papers at various conferences and journals throughout the world. The training provided by the three projects will be effective for several generations of water resources experts in Egypt and other countries where they might work.

SESSION V-A

EDUCATION IN WATER RESOURCES AND ENVIRONMENT

WATER AND ENVIRONMENTAL ENGINEERING EDUCATION, TRAINING AND RESEARCH AT TAMPERE UNIVERSITY OF TECHNOLOGY, FINLAND

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ABSTRACT

This paper describes a Finnish approach to develope water and environmental engineering programs based on observed needs in the field. The Institute of Water and Environmental Engineering of the Tampere University of Technology, Finland has rapidly expanded its activities since the establishment of the Chair in 1975. Current educational, training and research activities cover a wide range in the field of municipal and industrial water and environmental engineering. Other interests include water pollution control, multipurpose use of water resources and solid waste engineering. In addition, specific programs on water and sanitation engineering education are arranged for students from developing countries. Environmental engineering education program for students from East European countries with special reference to local environmental problems will begin in 1992. Research at the Institute has a strong emphasis towards developing new biotechnologies for pollution control and bioremediation. A new Environmental Biotechnology curriculum will be started in 1993.

JP, Visiting Assistant Professor at the University of Washington; PM, Graduate Student at the UW; SS, Senior Lecturer; MV, Professor, Head of the Institute of Water and Environmental Engineering

STAFF AND FACILITIES

The Institute has close to 40 staff members (5 permanent ones) and is directed by the professor. The majority of employees are financed by external funding. They comprise a multidisciplinary team representing various professional backgrounds such as water and sanitary engineering, environmental sciences, chemical engineering, microbiology and control engineering.

The IWEE laboratory is capable of conducting physical, chemical and microbiological water and wastewater analyses. Pilot and semi-industrial scale systems has been constructed for research on aerobic and anaerobic biological treatment. Research at the institutes field research station focuses on drinking water treatment.

EDUCATION AND TRAINING

Master of Science Programs

The Institute Offers two optional M.Sc. programs, one in Civil Engineering and one in Environmental Engineering. Both programs offer specialized studies in water and sanitary engineering. The new curriculum in Environmental Engineering was started in 1991 together with a number of other institutes at the university. Among others, it involves Environmental Biotechnology as a new specialization area. M.Sc. is the basic degree conferred by Finnish universities of technology requiring about 5 years of studies including a Master's thesis. By 1992, more than 100 students have specialized in water and sanitary engineering.

Licentiate and Doctoral Programs

The licentiate and doctoral degrees require the same theoretical studies, but the licentiate involves less scientific research. By 1992, over 20 licentiate theses and 8 doctoral dissertations have been presented and accepted at the Institute.

International Programs

IWEE has organized international training programs as follows:

Postgraduate Course in Water Supply and Sanitation, an 18-month M.Sc. course designed for the needs of developing countries. The first 12 months consist of studies in Tampere followed by a thesis period in the students home country. Since 1979, IWEE has organized six such courses for East African countries. These were financed by the Finnish International Development Agency (FINNIDA). By 1992, about 100 East African engineers have obtained their M.Sc. degrees.

B.Sc. Program in Civil Engineering for Namibian Students 1989-1992. This four year program is tailor-made providing specialized knowledge in water and environmental engineering. This course, also financed by FINNIDA has currently 15 students.

Doctoral Program. Four East African water engineers have obtained their doctoral degrees.

International Trainee program. During the period of 1978-1986 16 M.Sc. students had their one-year field training in Tanzania. In addition, several foreign IAESTE-trainees have received their practical training at the IWEE.

Environmental Management Program for East European engineers. Huge environmental problems and new possibilities for eastern-western cooperation stimulated this new educational effort. This program starts in September 1992. The course has a strong emphasis on waste treatment technologies and remediation of contaminated environment.

Continuing Education

* The Institute has arranged several international and national conferences, short courses and seminars including:

* IAWPRC Symposia on Forest Industry Wastewaters in 1984, 1987 and 1990. The next symposium will be held in 1993.

* 1st IAWPRC Eastern Africa Regional Conference on Industrial Wastewaters in Nairobi 1989, in cooperation with Kenyan organizers.

* WHO Meeting on Intersectoral Collaboration in Europe 1989.

* Environmental Management in Industries, a three-week course financed by UNEP and UNIDO in 1989 and 1991.

* Pulp an Paper Industry Wastewaters, a one-week course under the UETP/EEE program of COMETT in 1992.

* Annual National Symposium on Solid Wastes in 1987-1992.

* Several seminars on current topics in water and environmental engineering in Finland and developing countries.

RESEARCH

Research is typically associated with theses and dissertations but may also be based on the needs of clients. Experimental research has been focusing on water, wastewater and solid waste treatment process fundamentals and applications including studies in laboratory, pilot, and full scale. Theoretical research on treatment process modelling and water and waste management are also included. Current research covers following areas:

* Biological treatment of industrial and municipal effluents and wastes. During the last 10 years, biological treatment of pulp and paper industry effluents has been the major research area.

* Groundwater bioremediation

* Biological treatment of recalcitrant, toxic and accumulative organics

* Phosphorus and nitrogen removal

* Mesophilic and thermophilic anaerobic treatment

* Physical and chemical purification of water

* Mathematical modelling of treatment processes

* Institutional development of water and sanitation services

* Water problems in developing countries

The research is primarily funded by the Academy of Finland, the Ministry of Environment, the Ministry of Trade and Industry, the National Board of Waters and Environment, the Ministry of Foreign Affairs, various foundations, municipalities, private enterprises and international organizations.

IWEE has an active program for the exchange of researchers and lecturers with universities in e.g. Austria, Czech and Slovak Federal Republic, Denmark, Estonia, France, Germany, India, the Netherlands, Norway, Russia, Sweden, Tanzania, United Kingdom and the United States. IWEE participates in the TEMPUS program in environmental management.

CURRICULUM ISSUES IN APPLIED HYDROLOGY AND THE ENVIRONMENT

Mary Jessica Mack[1]

INTRODUCTION

Curriculums in higher education must be responsive to the requirements of the professions which the students will join upon graduation. Students must learn the methodologies and techniques necessary to address real world problems and at the same time gain an understanding of and an appreciation for the interdisciplinary aspects of hydrologic studies of the environment.

Environmental and hydrologic curriculums can not prepare a student for every concern, but curriculums can equip students to approach any topic. To properly enable students to be effective in their professions, the curriculum must provide the following background to the students: training in classical hydrology; an interdisciplinary background; exposure to real world applications; training in skills and a technical background; work experience and real world exposure.

An individual course can establish the students interests, and spark the intellectual pursuit by touching briefly in the areas identified above and by modeling the format of the curriculum. However, one course can not adequately provide the package the student will need to compete and survive in the profession. The necessary curriculum components are briefly reviewed below.

TRAINING IN CLASSICAL HYDROLOGY

Students need training in the classical hydrology background, the basics. A sound foundation in the elementary relationships and processes of water is the starting point. Students need to understand what water is, what forms it takes in the environment, and its importance in the total functioning of the earth system. They need an understanding of the hydrologic cycle and its components, of the properties of water, and of the states of water and its role in the transfer of energy.

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The meteorological and climatological aspects should be discussed as well as water's role in weather. The water in the atmosphere should be provided, including a background in evaporation, evapotranspiration and precipitation, their measurement, estimation, processes, interpretation and analysis. The water in the soil should also be reviewed including rainfall-runoff relationships; infiltration, percolation, stream flow; soil moisture; subsurface water; floods; drought; hydraulic routing, probability and stochastic hydrology and hydrologic analysis.

The computation of water budgets can be useful for helping students understand the relationships and influences of theses different areas of water in the environment. It will not take the student long to realize the study of hydrology in the environment requires a multidisciplinary knowledge base.

AN INTERDISCIPLINARY BACKGROUND

A responsible curriculum must therefore provide the student with an interdisciplinary background for the undertaking of hydrologic environmental studies. This background should include additional meteorological and climatological relationships including radiation and large-scale general circulation -- jet streams and fronts, and concerns such as global climatic change and the influences on local water resources. Students should be aware of water supply issues such as water modification, water supply manipulation, saline water conversion, vegetation control, water harvesting, and icebergs. Human issues should be addressed such as water demand, human interaction with and influence upon water resources and the legal, political, and economic influences on water management.

Students need some background in geologic and groundwater hydrology including the geology of aquifers, confined and unconfined aquifers, their storage capacity and mechanisms relating to their pollution and destruction. They need a working knowledge of hydraulic head and fluid potential, hydraulic conductivity, unsaturated flow, compressibility and stress, transmissivity and storativity. Groundwater movement should be addressed including Darcy's Law, equations of groundwater flow, chemical properties, flow nets, well dynamics and hydraulics, well development, levels, and protection. Other areas presented should include basin yield and water quality.

In addition to the interdisciplinary background, students must be able to make the step of taking the theoretical background and applying it to problems.

EXPOSURE TO REAL WORLD APPLICATIONS

Students need exposure to real world applications. Case study analysis can be used to illustrate a variety of applications of hydrologic studies in the environment. Also, simple problems can be provided for the students to "solve" using the knowledge presented in the class. This can give the student practice in the analysis of a specific case or cases requiring the student to analyze the situation and approach the problem.

This can provide the student with experience in data preparation, record extension, water supply reservoirs analysis, flood mitigation and routing, floodplain mapping, urban storm drainage estimation, highway culvert design, spillway design, cooling pond design, river forecasting, water quality analysis, hydrometric network design, water resources regional planning, river basin management, ground water resources evaluation, drought identification, solid and nuclear waste analysis, and groundwater contamination determination. It can also help the student understand the real world implications of current legislation and policy (federal, regional, and local).

The cases can be current issues that are in the process of being analyzed or recently managed problems. This can help keep the issues relevant and fresh while demonstrating the importance of understanding the material learned and the techniques of the application. The important factor is not for the student to arrive at the "correct" answer or the solution of the officials dealing with the case. The purpose is for the student to understand the factors involved, the methodologies which could be used to approach the case, even the different conclusions that could be drawn from the evidence based on the methodology chosen, and the advantages/ disadvantages, of the conclusions. The goal is to teach the students how to use their knowledge to approach the various problems they might be required to consider in the future.

In order to prepare the student for their future environmental analysis, the curriculum must also provide the student with skills and a technical background.

TRAINING IN SKILLS AND A TECHNICAL BACKGROUND

Curriculums need to provide training in skills and a technical background so that students are aware of the tools available to them for data collection, problem analysis and the presentation of results and solutions. A methodology and field work class in ideal for exposing the student to various methods and equipment for data collection. It is important for the student to be aware of the tools, their operational techniques, calibration requirements, and automated record keeping procedures. The applications, limitations, and idiosyncrasies of the methods and of the equipment need to be understood.

Research methods need to be explored, statistical analysis both long-hand and via computer programs, problem analysis via long-hand and computer models. Students should have the opportunity to understand how current computer models operate even if hand-on experience is not available. If a computer model is available, it needs to be one which is current and in use. Even so, special care should be taken to teach the student how to investigate the model (capabilities, limitations, default values, etc) and how to interpret the results from models. It is imperative for a student to understand that a "value" determined by a computer model could be nonsense if the model is not understood.

The curriculum also needs to provide the student with training and practice in presentation skills. Written communication should be required, technical writing courses are necessary so that the student learns the components and styles of technical memos and reports. Students should learn and be able to practice the effective use of tables, graphs and figures in written communication.

Oral communication, should also be stressed so that a student can learn how to give clear, concise presentations of the data and how to address different audiences. A student needs to know the difference between presenting findings to a panel of experts/peers as part of the problem-solving discussions, as opposed to the presentation of data to the government officials, which is different still from the presentation of information to a "town meeting" of concerned citizens. Curriculums need to provide students with opportunities to learn and practice the effective use of audio-visual equipment in oral presentation.

Even these skills and technical experience needs to related to the real world.

WORK EXPERIENCE AND REAL WORLD EXPOSURE

Work Experience

Departments need to provide opportunities for students to gain work experience before graduation. This is an area where the Department must work to establish relationships with community and government organizations willing to participate in the joint effort to educate our future leaders. Internships, co-operative programs with federal state and local government agencies as well as with industry and consulting firms, and mentoring programs can provide background and experience for students. These are opportunities for the students to apply their current knowledge while gaining additional insight into the applications of the information and the functioning of an organization. These connections could even lead to future employment opportunities.

Real World Exposure

Even if work experience opportunities are minimal the curriculum can still be designed to provide the students with real world exposure. There are many methods that serve to make students aware of the professionals in the area, their roles and responsibilities; guest presentations in the classroom, students interviews or contacts in the process of researching current concerns locally, regionally, nationally, globally. Invite these people to speak at the student group meeting. The department can even sponsor forums and speaker series to bring these people to campus. The key is to help the students increase their awareness and consciousness of the hydrologic studies and concerns of the environment at different scales.

CONCLUSIONS

Obviously, one course can not provide the preparation needed for a student to succeed in the profession. However, in a well designed curriculum the individual courses can have many of these components on a smaller scale. An individual course can be designed to complement and build on the knowledge base provided from previous courses. It can also be designed to model the components discussed above which the student needs to acquire to be prepared for the profession.

Thus, although educational institutions are not equipped to train individual students for specific jobs, curriculums in applied hydrology and the environment can be designed to provide the background necessary for students to join and excel in the professions responsible for the applied hydrologic studies and concerns of the environment.

HYDROLOGIC EDUCATION: THE NEED FOR A FIELD COMPONENT

Lee H. MacDonald[1]

1. INTRODUCTION

In 1988 the National Research Council convened a committee to guide science and educational policy decisions in hydrology. The resulting book, *Opportunities in the Hydrologic Sciences*, argues for and suggests means for building a stronger identity and unity in hydrologic science. Of particular relevance is the chapter on hydrologic education, where it states that a serious educational problem is **"the lack of field and laboratory experience at the undergraduate level, a situation that has reached crisis proportions"** (p. 287, NRC, 1991). This conclusion is strongly supported by a recent survey of hydrology courses at colleges and universities in the U.S. and Canada. The respondents described 73 undergraduate hydrology courses in civil engineering, but only two incorporated an experimental or field component (Groves and Moody, 1992). In contrast, three-fourths of the instructors required some computer-based work.

Clearly--at least at the introductory level--most undergraduates in hydrology are computer literate but receive no little or no training in field methods. The purpose of this paper is to examine the short and long-term implications of this deficiency, and suggest how a field-based course can be developed at minimal cost. For illustrative purposes a newly-revised course in watershed measurements is described. The modular nature of this course means that some or all of the units can easily be adapted.

2. RATIONALE FOR FIELD COURSES IN HYDROLOGIC EDUCATION

The relative absence of field and laboratory courses in hydrology has a number of short- and long-term implications. These include: (1) an unwarranted faith in published data; (2) a lack of appreciation for the spatial and temporal variability of most hydrologic processes; (3) a lack of appreciation for the difficulty of collecting good quality data; (4) an inability to design and execute projects to collect

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field data; (5) a lack of field experience which can be applied when confronted with different problems or new environments; (6) an inability to evaluate published materials or models against "field reality"; (7) excessive reliance and trust in theoretical or conceptual models; and (8) a reduced potential for lifelong learning through obervation and analysis. As noted in the afore-mentioned NRC report:

> "The consequences of this are both profound and disturbing. Students have become separated from the realities of the physical world they seek to master, studying only conceptual models in which the rich complexity of nature is replaced necessarily by the convenience of ad hoc simplification. In the absence of experimental validation, these models tend to take an aura of reality in the minds of the users, which may lead to scientific error and stagnation." (NRC, 1991, p. 287).

It should not be regarded as heresy to suggest that "field literacy" is of equal importance to computer literacy. The process of determining what to measure, where to measure, and when to measure exemplifies the scientific process in terms of identifying a hypothesis, establishing an experimental design, and then testing the hypothesis. The process of collecting data forces students--and in this sense we all are students--to recognize the spatial and temporal variability characteristic of virtually all hydrologic processes. Field data collection also forces an appreciation for the uncertainty and arbitrariness associated with single observations. The analysis and interpretation of the collected data is the final and arguably most important step in the scientific method. This step is probably the most difficult to teach and the one most commonly neglected in undergraduate courses. My personal belief is that all of these basic lessons are most effectively taught through courses which require students to collect and analyse data.

By guiding students through this process, a variety of other skills are developed. These include enhanced observational skills and an awareness of hydrologic processes in the field (e.g., can we determine whether Horton overland flow is the primary source of storm runoff?). Confronting the students with such questions forces them to be more critical of the typical simplifications inherent in the hydrologic models and empirical techniques commonly used by practicing hydrologists, and more aware of the complexity found in the real world.

Of particular concern is the long-term implication of omitting a field-based component in hydrologic education. The risk is that hydrologic science will become increasingly esoteric and unrealistic. If we consider that today's undergraduates are tomorrow's teachers and practitioners, will they be prepared to practice and teach in ways which are realistic and insightful? Will they have the knowledge and experience to advance this combination of art, craft, and science that we call hydrology? Or will we be caught in a downward spiral of more models and less data? The NRC report notes that the lack of field-based courses appears to be self-perpetuating (p.287).

In a recent address to the 300-plus hydrologists in the U.S. Forest Service, Dr. Luna Leopold noted that structured field observations are probably the single most important means by which hydrologists can advance their knowledge and capabilities. He noted that most organizations have very limited resources for training, and it is therefore incumbent on the individual to train themselves through a self-imposed regimen of observation and analysis. The most highly-repected hydrologists in the U.S. have already gone on record as strong advocates for a field-based education, and it is our responsibility as professional educators and hydrologists to ensure that the next generation is adequately prepared both for the tasks which lay before them and the life-long learning necessary for further progress.

3. MUST FIELD COURSES BE COSTLY AND DIFFICULT?

There are a variety of reasons why people often are reluctant to initiate field courses. First, field courses are presumed to require expensive equipment. Second, the field is unpredictable, and many teachers prefer situations in which they have more control and can retain the aura of omniscience. Third, many teachers themselves do not have much field experience, and there is a natural hesitation to teach topics in which one has little knowledge or experience.

The reality is that field courses do not necessarily require expensive equipment. Critical meteorolgic data such as precipitation and temperature can be measured very inexpensively. Plastic wedge-shaped rain gages can be bought for around $6 each, or students can simply use empty cans or wide-mouthed bottles. As long as the devices and measurement procedures are similar, the data can be compared and quantitatively analysed. Inexpensive thermometers are adequate for most purposes. Discharge measurements can be made with nothing more than a string, a couple of stakes, a line level, a tape measure, and an orange to be used as a float; the total cost of these items can be less than $20. Infiltrometers can be made from sheet metal, and determination of soil water content requires only a weighing scale and an oven.

The critical lessons to be learned in field courses is not a dependence on expensive equipment, but the process of designing a project, collecting the data, and analysing the data in a manner which is appropriate to the question being addressed. The same principles apply whether one measures precipitation with uses a tipping bucket rain gage or an old tuna can.

Clearly field courses are more unpredictable than lectures, but that in itself is an important lesson. Too often students have been led to expect a black-and-white world, but we know that the real world is a dynamic collection of interacting, non-linear processes. Often there is not a "best" procedure or a true value, and it essential that students recognize the limitations of our ability to measure and define everything of relevance to a particular problem.

4. WATERSHED MEASUREMENTS AT COLORADO STATE UNIVERSITY

The Watershed Science Program at Colorado State University is in the College of Natural Resources, and it offers B.S., M.S., and Ph.D. degrees. All undergraduate majors are required to take a two semester-credit course called Watershed Measurements. Normally this course is taken in the junior year, but many incoming graduate students enroll in this course because they have a limited background in hydrology. The stated purpose of the course is to cover the procedures for collecting a variety of field data, but the underlying objectives are much more diverse and of at least equal importance.

The course is taught during one three-hour lab period each week and a required one-day field trip (Appendix 1). The course is structured around two major exercises (meteorologic data collection and stream channel measurements) and a series of smaller exercises and field trips (Appendix 1). In the absence of a text, a course reader has been developed (Appendix 2). For copyright reasons this reader contains only materials published by the government or scientific organizations, as they generally are willing to allow limited duplication for nonprofit educational purposes. The current version exceeds 400 pages and thus must be regarded as more of a reference book than a true reader.

5. CONCLUSIONS

There is a serious deficiency of field-based courses in hydrologic education. This is a self-perpuating situation and has adverse consequences on the future development of hydrologic science and the competence of newly-graduated professionals. Field-based courses can be developed at minimal cost. Even if one does not initially have the necessary expertise, one often can draw on hydrologists within public agencies or even private consultants. In most cases professional hydrologists are quite willing to volunteer a few hours to teach a particular topic or assist with a field exercise. Very few communities lie outside the reach of hydrologists within the U.S. Forest Service, U.S. Geological Survey, or Soil Conservation Service. Every community has water resource issues which can provide the basis for a field trip and/or field measurements. The development of a field-based hydrology course requires only commitment, enthusiasm, and a willingness to learn and adapt.

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Appendix 1. Outline and content of the Watershed Measurements course at Colorado State Univ. (ER 417).

Objectives: The purpose of this course is to provide both a theoretical and practical knowledge of the most common types of measurements related to land use hydrology and watershed management. The course also will provide some training in collecting, analysing and presenting data in written reports. The methods used to achieve these objectives will include lectures, outside reading, directed field exercises, lab and homework assignments, field trips, and a take-home final exam.

Grading:

Major lab reports	
Climatic measurements	20%
Stream measurements	20%
Lab exercises (4)	30%
Take-home final	30%
Total	100%

Course Content and Schedule (1991):

Aug. 28	Course introduction, climate measurements;
Sept. 4	Stream classification; habitat types;
Sept. 11	Stream channel measurements (cross-sections, discharge, thalweg profile, bed material particle size, Manning's n);
Sept. 14	Field trip to Little South Fork of the Poudre River (approx. 8:00-5:00);
Sept. 18	Distribute data from field trip; other types of discharge measurements;
Sept. 25	Weather stations; visit to CSU station (N. Doesken);
Oct. 2	Topo maps (hypsometric curves, areal precipitation, drainage density, digitizer);
Oct. 9	Soil moisture;
Oct. 16	Infiltration and hydraulic conductivity;
Oct. 23	Field trip to Pawnee grasslands;
Oct. 30	Statistical design and paired watersheds;
Nov. 6	Sediment sampling;
Nov. 13	Field trip to Engineering Research Center;
Nov. 20	Snow measurements and runoff forecasting (SCS);
Nov. 27	Thanksgiving break;
Dec. 4	Framework and procedures for watershed analysis.

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SESSION V-B

COMPUTERS IN WATER RESOURCES EDUCATION

RULE BASED COMPUTING IN WATER RESOURCES: AN ALTERNATIVE TO PROCEDURAL LANGUAGES

Johannes Gessler *)

INTRODUCTION

In a survey among recent graduates of Georgia Tech 80% of the civil engineering students indicated that they did not "program". Why then do we continue to teach "programming", typically in the freshman year of our curricula? Is this strictly an academic exercise with no significance to the majority of the student at the time they enter their engineering career? "Programming" in the survey was defined as "programming in FORTRAN, Pascal, C, or perhaps BASIC".

But a fair number of former students indicated they were using "spreadsheets" on a regular basis. Talking to our own graduates at Colorado State reveals very similar results, though we do not have a extensive survey. We find that in fact, many engineers "program within spreadsheets".

We can define "programming" in a slightly broader sense: preparing computer/software tools to perform computations according to the instructions of the user. Such a definition includes "procedural programming" in such "classic" languages as from BASIC to C, but it also includes the manipulations of data sets in spreadsheets.

Many engineers who, due to lack of opportunity, have forgotten their procedural languages, put a great effort into manipulating spreadsheets to do their computational task, how inappropriate the tool might be. The fact is that spreadsheets provide very rigid, well defined frameworks the user can easily remember. But frequently the task would be easier if the program would be written in a procedural language. To phrase it pointedly: spreadsheets get extensively abused, simply because the engineers are uncomfortable with the use of more appropriate tools.

RULE BASED COMPUTING: TK SOLVER

A new category of programming tools includes the "equation solvers", one of which is TK Solver. The name "equation solver" implies that these are tools which solve sets of linear and non-linear equations. In addition TK Solver can serve as a very sophisticated spreadsheet, that is the equation solver can act on data sets. The equations involved can be much more sophisticated than what is possible in spreadsheets. And the "programming" of TK Solver is much simpler and faster than for either, procedural programming or spreadsheets.

There are two fundamental concepts which make TK Solver such a powerful tool: (a) the user does not have to worry about the numeric procedure used to solve sets of equations. TK Solver has a generic, built-in equation solver routine (a modified Newton-

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Raphson procedure) which it can enact automatically; (b) after a problem is programmed for a given set of input variables, this program ("model" in the TK language) can be solved for any other set of input variables. In other words the program can be turned around without the need of writing another code. In TK Solver language this capability is called backsolving. From a design point of view this is an extremely important feature.

Successful model building in TK Solver is a skill not so different from learning to program in FORTRAN. But learning to do so in TK Solver takes much less time. And model building in TK Solver takes only a fraction of the time it takes in FORTRAN. People experienced on both sides find that solving a particular numeric problem with TK Solver takes only 10 to 20% of the time it takes in FORTRAN.

PROGRAMMING OF WATER RESOURCES RELATED PROBLEMS

Hydraulics is a discipline dominated by non-linear equations, simply because momentum and energy equation are non-linear. In addition in water resources we deal frequently with large arrays of data ("lists" in the language of TK Solver). Both aspects make TK Solver a logical tool to use. In the following pages we illustrate the solution to one particular problem using TK Solver.

THE SAMPLE PROBLEM

Let us "model" the relationships between discharge, depth of flow and bed shear stress in an open channel, as a function of the geometry, specifically channel shape, roughness characteristics on the channel perimeter, and longitudinal slope. Note that we don't say: find the depth of flow for a given discharge (or visa-versa). In TK Solver, if we can do the first we can "backsolve" the problem as well, without the need of re-formulating the problem.

We will take this problem through a number of steps with ever increasing complexity until we have a rather realistic computer model of the process.

MODEL # 1

The normal flow equation in an open channel is

$$v = (8\, g\, R\, S / f)^{1/2} \qquad (1)$$

where v is the average velocity, g the acceleration due to gravity, S the channel slope, f the friction factor:

$$f = (2.21 + 2.03 \log(R/k))^{-2} \qquad (2)$$

with k the controlling roughness height and R the hydraulic radius

$$R = A/P \qquad (3)$$

where A is the cross sectional area and P is the wetted perimeter. Let us assume the cross section is trapezoidal, with a bottom width of W, a depth of D, and side slopes of 1 vertical : n horizontal. Then area A and perimeter P are given by

$$A = W\,D + D\,n^2 \tag{4}$$

$$P = W + 2\,D\,(1+n^2)^{1/2} \tag{5}$$

Finally the discharge is given as the product of area and velocity

$$Q = v\,A \tag{6}$$

Simply enter these equations ("rules") into the rule sheet of TK Solver. At this point in time we do not need to be concerned whatsoever what variable is given and what are the unknowns. As you enter the rules the variable names used will automatically be entered into the variable sheet.

Let us now assume we know the bottom width W, the channel slope S, the side slope n, and the depth of flow. We enter the given values into the variable sheet and tell

```
================== RULE SHEET ==================
S Rule-------------------------------------------
  ; Model 1: uniform roughness around perimeter

  v = sqrt(8*g*R*S/f)                    ; normal flow equation
  f = ( 2.21 + 2.03*log(R/k) )^(-2)      ; friction factor equation
  R = A/P                                ; hydraulic radius
  A = W*D + D*n^2                        ; area
  P = W + 2*D*sqrt(1+n^2)                ; wetted perimeter
  Q = v*A                                ; discharge

================== VARIABLE SHEET ==================
St Input---- Name--- Output--- Unit---- Comment--------------
               v      5.6809302         average velocity
   32.2        g                        acceleration due to gravity
               R      2.3560776         hydraulic radius
   .002        S                        channel slope
               f      .03761201         friction factor
   .08333333   k                        controlling roughness
               A      84                cross sectional area
               P      35.652476         wetted perimeter
   20          W                        bottom width of channel
   3.5         D                        depth of flow
   2           n                        side slope (1 vertical :
                                        n horizontal)
               Q      477.19814         discharge
```

Figure 1: Rule and Variable Sheet of Model 1.

TK Solver to "solve" the problem by pressing key F9. The answer in form of values for the unknown parameters will appear instantaneously in the "output column" of the variable sheet. In Figure 1 we show the rule and variable sheet of TK Solver with the above information entered and after the problem was solved.

Of course this is an easy problem, even if you use a hand-held calculator: given the depth you can find area and wetted perimeter, then the hydraulic radius and the friction factor, and finally the velocity. But note that to TK Solver it does not matter in which order you state the rules.

More challenging is the "reversal" of the problem: given the discharge, find the depth. Now we want to backsolve the problem. To solve it we do not need to change anything within the rule sheet. But in the variable sheet we re-assign values as above, with the exception of depth being unknown and discharge being given. We need to solve the resulting set of highly non-linear equations for the unknown D. Using any numeric technique we would need to provide a starting point for the solution in form of an estimated answer. We can instruct TK Solver to use a first guess of D = 1. Press F9 again and you get, after a few iterations, the answer (see Figure 2). Programming this problem in FORTRAN takes a considerable effort. Here finding the depth for a given discharge is just as easy as the opposite and does not require any additional programming.

VARIABLE SHEET

St	Input	Name	Output	Unit	Comment
		v	6.0372237		average velocity
	32.2	g			acceleration due to gravity
		R	2.5801139		hydraulic radius
	.002	S			channel slope
		f	.03647037		friction factor
	.08333333	k			controlling roughness
		A	99.383431		cross sectional area
		P	38.519009		wetted perimeter
	20	W			bottom width of channel
		D	4.1409763		depth of flow
	2	n			side slope (1 vertical: n horizontal)
	600	Q			discharge

Figure 2: Model # 1; The Variable Sheet for Finding the Depth of Flow for a Given Discharge.

MODEL # 2

We proceed with making the problem a little more general and more realistic. Let us assume that the side slope of the channel do not have the same roughness as the bed. We assume that they are rip-raped, providing a roughness on the sides of ks. The bed roughness we now call kb. It is customary to solve this problem under the assumption that the flow equation can be applied to three sub-cross sections, one each associated with the left side, the bottom and the right side. It is assumed that each of the sub-cross sections will have the same slope S and the same average velocity v. This leads to the following equations:

$$R / f = Rs / fs \tag{7}$$

$$R / f = Rb / fb \tag{8}$$

$$f = (W\, fb + (P-W)\, fs) / P \tag{9}$$

Here Rs is the hydraulic radius associate with the sides, Rb is the hydraulic radius associate with the bed, and fs and fb are the corresponding friction factors, defined as

$$fb = (2.21 + 2.03 \log(Rb/kb))^{-2} \tag{10}$$

$$fs = (2.21 + 2.03 \log(Rs/ks))^{-2} \tag{11}$$

We can add these new rules to Model # 1, but at the same time we have to remove the original equation for f, Equ. 2, since it is now replaced by the new equation for f, Equ. 9. The hydraulic radius for the total cross section, R retains its original meaning.

```
=========================== RULE SHEET ===========================
S Rule------------------------------------------------------------
  ; Model 3: different roughness for bed and sides.

  v = sqrt(8*g*R*S/f)                      ; normal flow equation
  R = A/P                                  ; hydraulic radius
  A = W*D + D*n^2                          ; area
  P = W + 2*D*sqrt(1+n^2)                  ; wetted perimeter
  Q = v*A                                  ; discharge
  R/f = Rs/fs                              ;] equations for
  R/f = Rb/fb                              ;] non-uniform roughness
  f = ( W*fb + (P-W)*fs ) / P              ; average friction factor
  fb = ( 2.21 + 2.03*log(Rb/kb) )^(-2)     ;] equations for
  fs = ( 2.21 + 2.03*log(Rs/ks) )^(-2)     ;] roughness coefficients
```

Figure 3: Rule Sheet for Model # 2

The problem now consists of ten equations. And even if depth is given it is no longer straight forward to solve for discharge. Rather it is necessary to solve the equations simultaneously. Again we need to provide a guess to get the built-in algorithm started. It is sufficient to guess at the beginning Rb to be equal to the depth of flow. In Figure 3 we show the new rule and variable sheet. Depth is given, discharge is to be found. The only new additional input variable is the rip-rap size ks. We use .667 ft.

St	Input	Name	Output	Unit	Comment
		v	4.5850128		average velocity
	32.2	g			acceleration due to gravity
		R	2.3560776		hydraulic radius
	.002	S			channel slope
		f	.057741		friction factor
		A	84		cross sectional area
		P	35.652476		wetted perimeter
	20	W			bottom width of channel
	3.5	D			depth of flow
	2	n			side slope (1 vertical: n horizontal)
		Q	385.14108		discharge
		fs	.07779211		friction factor for sides
		Rs	3.1742478		hydraulic radius for sides
		Rb	1.7157582		hydraulic radius for bed (guessed equal to depth)
		fb	.04204853		friction factor for bed
	.08333333	kb			controlling bed roughness
	.667	ks			controlling side roughness

VARIABLE SHEET

Figure 3 (continued): Variable Sheet for Model # 2

In Figure 4 we show the variable sheet for Model # 2 when we backsolve the problem, that is given the discharge, find the depth. We now need to guess two of the unknowns. We used depth and the hydraulic radius of the bed as variables to be guessed. For both initial guessing we used 1.

Most people find programming of this model in FORTRAN very difficult, especially the case of finding the depth, given the discharge. Typically it requires several hours to get the program to run. Of course you need two different programs, depending whether you are looking for depth or discharge. In TK Solver, building this model requires less than 1/2 hour. A good understanding of numerical methods is not required. The only "tricky" part is to decide what and how many unknowns to guess.

MODEL # 3

We continue to build more information into this model. In stable channel design one would have to ask whether the bed material would move under conditions used in Model # 2. The controlling factor is the Shields' parameter

$$SH = Rb\, S \,/\, (\, (sg-1)\, kb\,) \qquad (12)$$

We can add the rule to Model # 2 and solve it for depth given a discharge of 100 cfs. The resulting Shields' parameter is 0.037. This value is too high to guarantee a stable bed. Consequently we backsolve the problem: what is the discharge when the Shields'

St Input	Name	Output	Unit	Comment
	v	5.0304149		average velocity
32.2	g			acceleration due to gravity
	R	2.8247032		hydraulic radius
.002	S			channel slope
	f	.0575097		friction factor
	A	119.27446		cross sectional area
	P	42.225483		wetted perimeter
20	W			bottom width of channel
	D	4.969769		depth of flow (guessed as 1)
2	n			side slope (1 vertical: n horizontal)
600	Q			discharge
	fs	.07322478		friction factor for sides
	Rs	3.5965809		hydraulic radius for sides
	Rb	1.9669355		hydraulic radius for bed (guessed as 1)
	fb	.04004593		friction factor for bed
.08333333	kb			controlling bed roughness
.667	ks			controlling side roughness

Figure 4: Model # 2; The Variable Sheet for Finding the Depth of Flow for a Given Discharge.

parameter reaches its allowable maximum of 0.023? Just assign .023 to the Shields parameter and make the discharge an unknown. The result may be unsatisfactory from a design point of view: the discharge is only 37 cfs. We then may ask yet another question: for a discharge of 100 cfs, what width of the channel bottom would be required to keep the Shields' parameter at 0.023. Simply make the width an output variable, specify the discharge to be 100 cfs, and the Shields' parameter to be 0.023, see Figure 5.

The only difficulty we run into has to do with the question what variables and how many to guess. After a few minutes of experimentation one finds that guessing the average friction factor (0.05), the depth of flow (1.0) and the hydraulic radius of the side will work.

CONCLUSION

Writing a procedural computer program for Model # 2 or 3 would consume many hours. Using TK Solver a model for our sample problem can be built in about 30 minutes. Not only do we save time, but the TK model can solve for any set of unknowns without the need of changing any rules. With minimal time investment the user can solve numerous "what if" problems. The result will be a better design which requires less time.

```
===================== RULE SHEET ==============================
S Rule----------------------------------------------------------
  ; Model 3: Model # 2 with Shields Parameter.

  v = sqrt(8*g*R*S/f)                     ; normal flow equation
  R = A/P                                 ; hydraulic radius
  A = W*D + D*n^2                         ; area
  P = W + 2*D*sqrt(1+n^2)                 ; wetted perimeter
  Q = v*A                                 ; discharge
  R/f = Rs/fs                             ;] equations for
  R/f = Rb/fb                             ;] non-uniform roughness
  f = ( W*fb + (P-W)*fs ) / P             ;  average friction
                                          :  factor
  fb = ( 2.21 + 2.03*log(Rb/kb) )^(-2)    ;] equations for
  fs = ( 2.21 + 2.03*log(Rs/ks) )^(-2)    ;] roughness coefficients
  SH = Rb*S / ((sg-1)*kb)                 ;  Shields' parameter

===================== VARIABLE SHEET ==========================
St Input---- Name--- Output--- Unit---- Comment------------------
                v      2.256629          average velocity
   32.2         g                        acceleration due to gravity
                R      .65036714         hydraulic radius
   .002         S                        channel slope
                f      .06579821         friction factor (guesses
                                         as .05)
                A      44.313885         cross sectional area
                P      68.136722         wetted perimeter
                W      65.276025         bottom width of channel
                D      .6396713          depth of flow (guessed
                                         as 1)
   2            n                        side slope (1 vertical :
                                         n horizontal)
   100          Q                        discharge

                fs     .12916872         friction factor for sides
                Rs     1.2767382          hydraulic radius for sides
                                         (guessed as 1)
                Rb     .62291667         hydraulic radius for bed
                fb     .06302102         friction factor for bed
   .08333333    kb                       controlling bed roughness
 .667         ks                        controlling side roughness
   .023         SH                       Shields' parameter
   1.65         sg                        specific gravity of gravel
----------------------------------------------------------------
```

Figure 5: Backsolving Model # 3 for Channel Width.

Educational Software for Reservoir Management

by

Darrell G. Fontane and John W. Labadie[1]

ABSTRACT: Reservoirs are an integral part of water resources management systems and the use of computer models is standard practice in reservoir operation. Unfortunately, students usually have limited exposure to reservoir management concepts and limited computing backgrounds. The authors discuss the use of various micro-computer based reservoir operation programs that have been developed or adapted for educational purposes in the Department of Civil Engineering at Colorado State University. This paper overviews the philosophy behind the design and use of this software and integrated student exercises. The authors provide their assessment of the value of using this educational software.

INTRODUCTION: The Department of Civil Engineering at Colorado State University (CSU) offers graduate courses that emphasize water reservoir management from a systems engineering perspective. Most students come into these courses with little background and understanding of reservoir management concepts and issues. Undergraduate programs devote little or no time to this complex task and public perceptions of reservoirs, their impacts on the water resources systems and their management considerations are limited at best.

Computer models are an integral part of the operation of modern water resources systems. The operation of reservoirs must increasingly satisfy multiple purposes such as flood control, water supply, recreation, wildlife protection and water quality maintenance. Further, reservoir system operation must consider the spatial, temporal and stochastic nature of water resources. Computer models can simulate the water resources system and provide valuable insight into the basic operational principles and help quantify tradeoffs between the various system purposes. Therefore, courses in reservoir

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management need to provide understanding of modeling concepts and the role of the computer models in management. Unfortunately, many students have a limited computing background and the use of the computer becomes a "barrier" that must be overcome rather than an aid in the learning process. In all honesty to the students, traditional water management computer models are complex and rather difficult to use.

Within this context, the authors have been working to integrate information and computing technologies into their courses at CSU with the overall purpose being to improve the educational experience for the student. Specific goals for incorporating educational software are identified in order of priority:

1. Improved understanding of the basic concepts of reservoir management.
2. Improved understanding of selected mathematical algorithms for simulation and optimization as applied to the reservoir systems.
3. Improved understanding of the role of computing in reservoir management.
4. Improved understanding of the basic concepts of computing.
5. Expose students to "typical" models that they may encounter in practice.

Existing water management software was developed for operational support, not for teaching. The educators' dilemma is how to incorporate the existing water management software into their courses or develop new educationally focused software that enhances the students understanding of the basic concepts without requiring a inordinate effort from the student to use the software.

The problem is focused both on the software itself and how the software supports the course objectives. The authors define their efforts as creating "courseware" which they define as adapted software with integrated student assignments. This paper will discuss the courseware currently being used in the introductory graduate course in water resources systems analysis, CE 546, taught in the CE department at CSU. It should be noted that much of this courseware has also been used by the authors in international short courses. Some of the software is applicable at the undergraduate level.

COURSEWARE: The software used in the CE 546 course is listed in Table 1 in order of its introduction into the course. All software is micro-computer based and available in a micro-computer student laboratory. The guiding principal of all the software is that it be easy to use, interactive and menu driven. Graphical displays are used whenever possible to assist in understanding the model results. Interfaces have been developed for existing operational models to adapt them to the educational purposes of the course.

The use of the models in the course has been designed to provide progressive exposure to the underlying operational concepts. As an example, the students begin the course by using the RESEXP model in the Manual mode. The student "plays" reservoir operator by trial and error. They find by experimentation how normal, drought and flood operations differ. They begin to get an intuitive feel for contingency planning. Hopefully they also begin to get curious about how the simulation process works and how they can systematically improve their operation of the reservoir. As the students are exposed to the mathematical concepts behind the simulation models, they move to the RESIM and RASHH models to develop and test consistent operational policies using longer time horizons. They are then introduced to optimization approaches, using the CSUDP software, for developing operational policies which they can compare to the policies they developed by trial and error. They go back to the RESEXP model and evaluate the expert system operations which are based upon a combination of optimization and operator experience. Finally the students are introduced to water quality simulation and control and multiple reservoir system management.

Coordinated student exercises complement the educational software. Students are exposed to a variety of reservoir situations based upon data sets from various sizes of rivers throughout the world. However, the exercises used during each specific offering of the course focus primarily on a single data set. Therefore, the students are continually applying progressively more complex techniques to the same set of data. The students rapidly gain familiarity and a feeling for how the reservoir should operate and this enhances their understanding of what the various techniques are providing. This is particularly important in assisting students to

TABLE 1 - Educational Software used in the CE 546 Water Resources Systems Analysis Course

Model Name	Model Purpose
RESEXP [PROLOG]	Single Reservoir Monthly Simulation for a 1 Year Horizon. Two User Modes: a) MANUAL Mode - User Specifies the Monthly Release Quantity b) EXPERT Mode - Built in Expert System Rules Determine the Monthly Release
RESIMW, RESIMWP RESIMR, RESIMWS [QUATTRO PRO 3 Spreadsheet]	Single Reservoir Monthly Simulation for 10 Year Horizon. Simulates User Specified Operational Rules. Different Models are Used for Different Types of Operational Rules.
RASHH [QuickBASIC]	Single Reservoir Monthly Simulation for Up to a 50 Year Horizon. Simulates User Specified Operational Rules. Has the Capability to Generate Stochastic Inflow Traces. User chooses to Simulate with Historical or Stochastic Inflow Data.
CSUDP [FORTRAN]	General Dynamic Programming Software. Template Subroutines Provided to Assist Students in Using Dynamic Programming for Optimizing Reservoir Operation for Single of Multiple Reservoirs. QUATTRO PRO 3.0 Interface for Reservoir Input and Output Analysis.
WESTEX [FORTRAN]	Corps of Engineers One-Dimensional Reservoir Thermal & Conservative Quality Daily Simulation. Predicts Reservoir and Release Water Quality and Determines Selective Withdrawal Operational Strategies. QUATTRO PRO 3.0 Interface for Model Input and Output Analysis.
MODSIM [FORTRAN]	General Multiple Reservoir System Simulation Software. Employs a Network Flow Algorithm to Distribute Water in a River-Reservoir System considering Water Use Priorities. Used in this course to Demonstrate System Operation Concepts.

understand optimization techniques whose results may not always be immediately "intuitively obvious". The students are encouraged to discover and share their perceptions of the advantages and disadvantages of the various approaches.

The exercises are designed such that each time a new model is introduced, students return to earlier models they are now familiar with to help them evaluate the value of the new model. This helps to build experience in using computer models and developing independent, critical evaluations of the approaches presented in the course. The primary focus of the exercises is not on using the models, but on reservoir management. Exercise questions focus on how to operate the reservoir during critical periods, describing operational strategies, etc. The student's goal is clearly understanding reservoir management techniques, not computer programming.

EXPERIENCES: The authors have a significant combined experience in teaching the CE 546 course and other water resources courses at CSU. The effectiveness of the software has been subjectively evaluated considering student evaluations, student performance on examinations and perceived students' understanding of the basic concepts. Overall the authors are convinced that the educational software has a symbiotic relationship in the courses and contributes immensely to the students' understanding of the material. The authors plan to continue expanding their courseware resources and its implementation in their courses at CSU.

However, the contribution of the courseware is not always universal. Often the largest realized benefit of the courseware is to the brightest students, with progressively less benefits to students with lesser academic abilities. Students with some experience in reservoir management also seem to gain significantly from the courseware. Unfortunately, some of the poorer students can be intimidated by the software even with additional one-on-one help. Since these students are confused about the software, they may become even more confused about the concepts the software is trying to illustrate. Often they can rapidly learn to use the software since it is menu driven and user friendly, however, they never seem to make the connection to the concepts of reservoir management which is the goal of the course. For these students, the software may actually be a detriment. Therefore, it is important that instructors using such courseware carefully monitor students' progress to identify those having difficulty and attempt to find other ways to help them grasp the important material.

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USER FRIENDLY COMPUTER PACKAGES IN EDUCATION: A CASE STUDY THE FLODRO PACKAGE

by

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ABSTRACT

The use of personal computers have changed dramatically the way to perform several studies related with hydrological problems. The increased capabilities of the current generation of personal computers allow the hydrological engineer to explore options that a few years ago were unthinkable without a mainframe computer. This fact had an important impact in education and training of water resources engineers, too.

Within this stream of development, user-friendly personal computer package FLODRO was developed. It has two components in the form of independent programs: FLOOD and DROUGHT, which perform flood and drought frequency analyses by using six distribution functions for the latter case: Normal, Log-Normal, Pearson Type III, Log-Pearson Type III, Extreme Value Type I and General Exterme Value. Four distribution functions are used in the former case : Three Parameter Log-Normal, Pearson Type III, Extreme Value Type I and General Extreme Value.

The characteristics, properties and construction of the of computer package FLODRO are displayed in the paper towards its application in flood and drought frequency analysis. The selected methods of estimation of parameters are those of moments and maximum likelihood for flood analysis and moments for drought analysis.

Several examples of application are shown in the paper, which is illustrated with several graphs to show the capabilities of modeling of the computer model.

INTRODUCTION

A subject of paramount interest in planning and design of water works is that related with the analysis of flood and drought frequencies. Due to the characteristic that design values, in both flood and drought analyses, are linked to a return period or to a non-exceedance or exceedance probability, the use of mathematical models known as probability distribution functions it is a must.

Among the most widely used probability distribution functions for hydrological analyses are the following, Kite(1988), Matalas(1976) and Salas and Smith(1980):

a) For flood frequency analysis: Normal, Log-Normal with 2 and 3 parameters, Gamma with 2 and 3 parameters, Log-Pearson type III, Extreme Value type I and General Extreme Value.

b) For drought frequencies analysis: Log-Normal with 3 parameters, Gamma with 3 parameters, Weibull, Extreme Value type I and General Extreme Value.

In the light of the personal computer applications in education and training in all the fields of science, a personal computer program was designed to take care of the processes of flood and drought frequency analyses, providing a wide number of options in the models to be used as in the analyses that can be done with such a tool as well. The resulting code has been named FLODRO as it will be referred herein. The paper contains the key features of FLODRO and two examples, one for floods and one for droughts, are included to show the main results that FLODRO can supply to the user.

FRAMEWORK OF FLODRO

FLODRO is written in GWBASIC™, a BASIC compiler compatible with IBM™ personal computers. The interactive mode in which FLODRO is written makes it to have a high user-friendly component. In any step, the user has control on the processes that the program executes, from data input to printing of results of the analysis.

The personal computer package FLODRO has the structure shown in figure 1.

All the probability distribution functions mentioned in the previous section are contained in FLODRO. FLODRO is divided in two independent computer programs: FLOOD and DROUGHT.

In the FLOOD computer program, the flood frequency analysis is performed by the use of seven probability distribution functions, as it is shown in figure 1.

- FLODRO →
  - FLOOD →
    - INFORMATION
    - NORMAL
    - LOG-NORMAL 2 AND 3 PARAMETERS
    - GAMMA 2 AND 3 PARAMETERS
    - LOG-PEARSON TYPE III
    - EXTREME VALUE TYPE I
    - GENERAL EXTREME VALUE
  - DROUGHT →
    - INFORMATION
    - LOG-NORMAL 3 PARAMETERS
    - GAMMA 3 PARAMETERS
    - WEIBULL
    - EXTREME VALUE TYPE I
    - GENERAL EXTREME VALUE

Figure 1. Framework of computer package FLODRO

In the DROUGHT computer program, the drought frequency analysis is performed by the use of five probability distribution functions, as it is shown in figure 1.

Both programs can perform the options shown in figure 2.

OPTIONS→
- INFORMATION
- ESTIMATION OF PARAMETERS
- COMPUTATION OF THE DENSITY FUNCTION
- COMPUTATION OF CUMULATIVE DISTRIBUTION FUNCTION
- INVERSE OF THE CUMULATIVE DISTRIBUTION FUNCTION
- COMPUTATION OF CONFIDENCE LIMITS
- GOODNESS OF FIT TESTS

Figure 2. Options of analysis in computer package FLODRO

Personal computer program FLODRO has been designed to use minimum of memory and computer peripherals. Each computer program FLOOD or DROUGHT have less than 360K, so there is no need to have a hard disk to run any of such programs. The graphs provided by FLOOD or DROUGHT are printed in a common printer, there is no need to use costly plotters to get in paper these graphs. These features makes FLODRO very suitable in programs of hydrology education and training, particularly in developing countries, and in continuing education as well.

NUMERICAL EXAMPLE

Gauging station Villalba has been selected to analyze the annual floods and the one-day low flow, in the period of record 1939-1981, using the Log-Normal 3 parameters probability distribution function.

The graphic displays provided by FLODRO are contained in figures 3 and 4.

CONCLUSIONS

A personal computer program has been presented for flood and drought frequency analyses education and training. The computer code has been applied successfully to train students coming from Latin American and African countries, showing the user-friendly component of such computer code given that most of the students have not have any previous computer experience. Due to the minimum requirements of central memory and computer peripherals that the personal computer program has, as it has been shown in the paper, makes it a versatile tool to train students or technical personnel in the field or with a personal computer without a hard disk nor a plotter.

ACKNOWLEDGEMENTS

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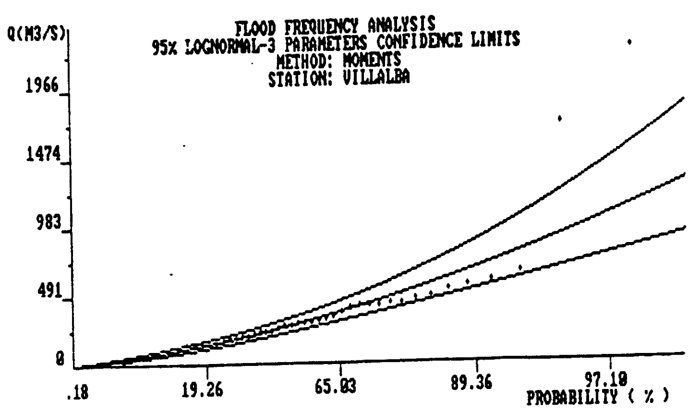

Figure 3 Flood frequency curve for station Villalba

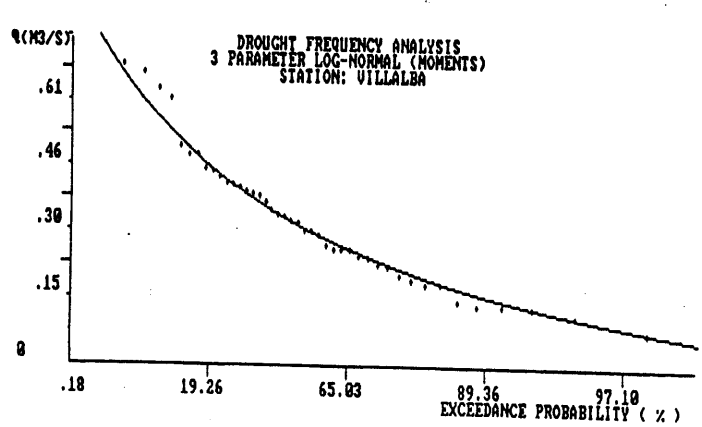

Figure 4 Drought frequency curve for station Villalba

SESSION V-C

OUTREACH PROGRAMS IN WATER AND ENVIRONMENT

The Groundwater Education in Michigan (GEM) Program: A Community-Based Model

Jessica T. Kovan and Linda W. Helstowski *

INTRODUCTION

Water is a critical factor in almost every aspect of society, yet we often take its quality and quantity for granted. Unseen and unheard...this is especially true of the groundwater resource. About half of Michigan's nine million residents rely on groundwater as their sole source of drinking water. Concerns about a safe supply of drinking water for present and future generations prompted the creation of the Groundwater Education in Michigan (GEM) program.

The GEM program was initiated in 1988 through a unique partnership between the Institute of Water Research at Michigan State University (MSU) and the W.K. Kellogg Foundation to explore opportunities for changing the way Michigan citizens think and act about groundwater. The GEM program is focused on promoting the development of action-oriented community-based groundwater education and protection projects. As a result, over 32 local groups and universities have initiated groundwater projects reaching a myriad of audiences in communities throughout the state. This paper describes the GEM program, the roles of the different organizations involved, and the elements that have led to a successful statewide groundwater education and protection program.

THE GROUNDWATER EDUCATION IN MICHIGAN (GEM) PROGRAM

Groundwater is a resource on which Michigan citizens are heavily dependent. About 530 million gallons of groundwater are withdrawn per day in the state; 41 percent is used for public water supplies, 30 percent for domestic uses in rural areas, 14 percent for irrigation, 12 percent is drawn by industry from its own wells, and 3 percent for livestock.

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Encouraging citizens in communities throughout the state to take action to protect groundwater quality is the primary focus of the GEM program. Program goals include: increasing public understanding of the groundwater resource; promoting individual and broad community involvement in developing groundwater protection initiatives; and supporting the development and implementation of pollution-prevention strategies at the local level. As a result, there is a heightened awareness of groundwater across the state and a better understanding among citizens of the relationship between their actions and the quality of the environment, particularly groundwater.

Developing a Statewide Strategy

An important objective of the GEM program has been to promote a thriving statewide network of local groups involved in community-based groundwater education and protection initiatives. In addition to providing support for community projects, "regional centers" have been established at academic institutions to provide assistance to local projects, as well as conduct their own projects.

From 1987 to 1990, the program's priority was on groundwater education. As projects were initiated throughout Michigan, citizens learned more about the fragile nature of groundwater and the need to protect its quality. In 1990, to capitalize on the enthusiasm and commitment generated by local GEM projects and to combat the increasing number of environmental contamination sites in the state, the focus of the GEM program was enlarged to include community-based groundwater protection projects. The orientation of this new focus is on empowering communities to maintain quality drinking water supplies.

The statewide GEM network includes the W.K. Kellogg Foundation, the Institute of Water Research, regional centers, and local projects; and clear linkages have developed among all four. As an analogy, it is useful to think of the GEM program as a wagon wheel. The Institute and the Foundation form the hub of the wheel, the regional centers the spokes, and the community projects the rim that holds the whole program together. All involved in this statewide program have benefitted from the diverse expertise, skills, facilities, and support of the universities, the Foundation, and the local groups.

Most important to the success of the program has been the identification of what needed to be accomplished in each particular community to protect groundwater and the targeting of appropriate audiences to be reached.

<u>The Institute and Foundation Role</u>
The Institute and Foundation have worked jointly to foster community-based projects and generate proposals for the GEM program. Staff have provided information and one-on-one assistance to many organizations interested in developing groundwater education and protection projects tailored to their particular community. Follow-up support in the way of phone contacts and feedback on preliminary project ideas has also been provided. This assistance has proven to be critical. In many cases, a community group may have little experience in looking for funds to reach those goals or in developing an outreach program specifically about groundwater.

Activities to promote networking and information sharing among the local groups are also important components of the GEM program. Outreach activities conducted by the Institute and Foundation include; networking conferences for all projects; a computer communications system (GEMNET); a database of educational resources; a newsletter exclusively for project participants; and various special events. As a result, a close comradery of colleagues across Michigan has been established to protect groundwater. This comradery has also been enhanced through the promotion and dissemination of project activities and materials. For example, a public service announcement for television featuring third graders performing a "GEM Rap" has been produced and is airing statewide to help spread the word about GEM community activities. In addition, the Institute maintains a computerized clearinghouse of all the materials being developed by the various projects to help prevent "reinventing the wheel."

With networking as a priority, the GEM program has been instrumental in building a unified force to help protect groundwater quality and, thereby public health, in the state. The GEM logo is being used statewide on all products by GEM projects and is easily identifiable. This logo has helped to provide a sense of participation in a larger program and given local projects the feeling of ownership in statewide activities.

Regional Centers

While the primary responsibility for preventing groundwater contamination rests at the local level, local officials often do not have the full information or expertise needed to take the action necessary to protect groundwater. To help meet this challenge, six regional groundwater centers have been established across the state in academic institutions. In general, each regional center has four main objectives: 1) to increase the public understanding of groundwater problems; 2) to enhance groundwater quality by serving as a regional hub in a statewide groundwater education network; 3) to cooperate and assist with local groundwater education projects; and 4) to facilitate more interactive and responsive local, regional, and state government within the groundwater arena.

The centers work to achieve these objectives through such activities as education, community assistance, and data collection and analysis. Each center conducts outreach activities within a specified region varying from three counties to 13. Though the regional centers have similar objectives, each one has its unique aspects and expertise. For example, Western Michigan is working with data rich and data poor counties and the University of Michigan is training teachers statewide with hands-on "Classroom GEMS" groundwater curriculum.

Community Projects

A variety of model action-oriented groundwater projects aimed at many different audiences have been initiated through the program. For example, a toll-free hazardous waste hotline is available for citizens and small businesses to call for assistance; a traveling classroom brings groundwater education into inner city schools; a nitrate testing training program exists for migrant farm aides; and forums for local officials, and youth and adult leadership teams have been offered. The following statement from Peggy Johnson of the Clinton River Watershed Council reflects the impact of supporting projects at the local level. She notes, "Groundwater education is reaching those people who are making decisions day in and day out which can influence whether our groundwater is going to be clean or contaminated in the future."

As a direct result of these innovative projects, the general public, children, teachers, well drillers, local officials, farmers, realtors, businesses, septic system contractors and many more are being reached about the importance of pollution prevention. In turn, they are educating others in their communities. The efforts and commitment at the local level, combined with sharing information and lessons learned among GEM projects, have been a key to the program's effectiveness.

EXTENDING THE IMPACT

Institutionalization, or having efforts continue after funding is completed, is a critical element of the GEM program. Although the W.K. Kellogg Foundation has provided initial seed funding for the program, each project is required to have a strong evaluation and institutionalization component. This element enables the groups involved to build on the success of their GEM projects to further develop their organization as a pollution prevention advocate.

In addition to working with local groups and universities, the program also coordinates efforts with statewide agencies and organizations. This includes producing a newsletter with national and international circulation, hosting regional conferences, distributing GEM educational materials as models, and maintaining a computer database of the most effective groundwater publications from around the country. The GEM program is committed to garnering support for groundwater protection statewide, as well as sharing information with other states, since groundwater knows no boundaries.

CONCLUSION

The GEM Program is helping to empower local groups to take action in their communities to protect drinking water quality. In turn, people across the state, from teachers to township planners, are understanding the connections between their activities and groundwater quality. "Spinoff" effects, new groundwater education and protection activities stimulated by the GEM projects, which generate yet more activities, are evident. This "chain reaction" is like additional drops striking the surface of an already rippled pool of water. The GEM program strives to foster and strengthen the linkages among these groups actively protecting groundwater. With its success thus far, this network will undoubtedly continue in the years to come.

AN INTERNATIONAL APPROACH TO GREAT LAKES EDUCATION

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INTRODUCTION

The International Joint Commission, a binational organization formed by Canada and the United States in the Boundary Waters Treaty of 1909, has identified the important role of environmental education in restoring and protecting the two countries' grandest boundary waters, the Great Lakes. "A strong and coordinated approach is required by the educational system to instill in children a sustained awareness and respect for the interdependence of all elements of the ecosystem, as well as a desire to act on this knowledge. Today's youth will make tomorrow's decisions as consumers using the knowledge and values gained, for the most part, from their education experiences."

Education Initiatives Crucial to Great Lakes Cleanup Efforts

The Great Lakes have a pervasive influence on the economy, environment and quality of life of millions of citizens in the United States and Canada. And yet, formal education on the Great Lakes and issues affecting them is extremely limited, and in fact, is not a required part of curricula in any state or province in the region. Studies in the early 1980s found that as many as 60 percent of students in Great Lakes states could not even name all five lakes.

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To encourage development of this coordinated approach, the Commission specifically recommended that both countries incorporate the Great Lakes ecosystem as a priority topic in existing school curricula and encourage the states and provinces to use Areas of Concern as focal points for the development of educational programs and materials. The Commission has investigated pollution problems in the Great Lakes several times over the past eight decades. A series of reports in the 1950s and 1960s led to the development of the Great Lakes Water Quality Agreement, signed in 1972 by Canada and the United States to eliminate pollution that was causing excessive algal growths, or eutrophication, in the lakes. Programs established under the Agreement limited the amount of phosphorus and nitrogen pollution that could enter the lakes as a result of human activities, and by the mid-1970s the lakes showed definite signs of improvement. At the same time, scientists began to find increasing numbers of toxic substances in the water, fish and wildlife of the region. These contaminants resulted from continued discharges of pollution from industries, and as a result, the two governments negotiated a second Great Lakes Water Quality Agreement in 1978 to address these issues. The 1978 Agreement was again revised in 1987 to include development of programs to address other sources of pollution, such as atmospheric deposition, groundwater and contaminated sediment.

The major emphasis of the revised 1978 Agreement is the need to understand and control the input of toxic substances into the Great Lakes. The overriding goal, in fact, is to eliminate the discharge of persistent toxic substances into the ecosystem. The Agreement calls for cooperative programs among the federal, provincial and state governments, communities and municipalities to define the total toxics impact to the lakes, and to develop better controls and programs in order to reach this goal.

Perhaps the most unique characteristic of the 1978 Great Lakes Water Quality Agreement is the requirement to develop programs which incorporate an Ecosystem Approach. The two countries recognized that the water, air, land, wildlife and humans are all interdependent, and that actions which affect one part of the ecosystem will impact all other parts of the system. Thus, programs established to accomplish Agreement goals must consider not only the level of water quality, but also the environmental, social, economic, political and institutional aspects of human actions which affect the quality of Great Lakes waters. In essence, the 1978 Agreement laid the groundwork for the region to begin considering Great Lakes water quality issues according to a sustainable development of integrated approach, long before the World Commission on Environment and Development presented its findings.

The "Great" in the Great Lakes

Geologically speaking, the Great Lakes are only in their infancy. They were formed some 11,000 years ago when the last glacier receded from the region. As an international border, the Great Lakes-St. Lawrence system extends almost 2,400 miles from Duluth to the Atlantic, the same distance between the shores of New York and France. The lakes total some 95,000 square miles in area, approximately the same size as Great Britain.

Lake Superior is the world's largest, freshwater lake by surface. It is the coldest, the deepest and the least polluted of the five lakes. Water entering the lakes will stay there for almost 200 years.

Lake Huron is the second largest of the Great Lakes, contains 30,000 islands, and is the fifth largest lake in the world. Lake water retention time is 22 years.

Lake Michigan, the third largest of the Great Lakes is the only one entirely within the United States and sixth largest lake in the world. Although similar in size and depth to Lake Huron, it has a longer retention time of 99 years because water enters and exits through the same path, slowing circulation.

Lake Erie is different from the other lakes in that it is shallow, warm, lies on rich soil and averages 95 percent winter ice cover and has a retention time of only three years.

Lake Ontario, slightly smaller in area than Lake Erie but much deeper, holds four times the amount of water. Eighty percent of the water supply comes from the upper lakes, the remainder from precipitation. Retention time for water entering Lake Ontario is six years.

Citizens in the Great Lakes basin have enjoyed and used the wide variety of natural resources of the region for many purposes over the centuries. At least 38 million people call the Great Lakes basin their home. The population of the region has grown more than 100 times in the last 170 years, and is expected to double in the next 40 years. Twenty-six million people rely on the lakes for their drinking water and account for daily withdrawal of 45 billion gallons. More freighters and cargo tonnage pass through the five locks at Sault Ste. Marie each year than through the Suez and Panama Canals combined. Because of ample supplies, industries that require water in their manufacturing processes have made the Great Lakes the industrial heartland of both Canada and the United States.

Status of Great Lakes Water Quality

While considerable progress has been made to resolve some water quality problems, and despite the development of an Ecossytem Approach in the 1978 Agreement, the Great Lakes ecosystem's present condition does not meet the Agreement's objectives in many ways. Surveillance data have shown that objectives are exceeded in waters surrounding many industrial and municipal outfalls, and as a result of pollution entering the lakes from the atmosphere, from urban and rural land runoff, from groundwater and contaminated sediment, and from spills and accidents.

All connecting channels in the Great Lakes system (the St. Marys, St. Clair and Niagara Rivers and Lake St. Clair) and 39 other specific sites have been designated Areas of Concern, locations where significant pollution problems exist and plans must be developed to remediate these sites. While local sources of pollution are major contributing factors, these areas reflect the combinations of stresses that affect all sections of the lakes and contribute to pollution problems in downstream receiving waters, such as the St. Lawrence River.

Despite warnings about the dangers of toxic chemicals, the number of these substances entering the Great Lakes Basin Ecosystem continue to expand. Often these materials enter the environment from unknown places with unidentified or poorly understood impacts, especially with respect to the long term. Fish and wildlife research provide an example of the extent of this problem: data has clearly shown that toxic substances are being accumulated by fish in many areas of the ecosystem, and deleterious health effects in wildlife populations have clearly been tied to levels of toxic contaminants in various species.

Although the human data are limited, it is reasonable to presume that toxic chemical exposures are adversely affecting human health as well throughout the ecosystem. While these effects may not be life-threatening at a personal level, they may have a significant effect on the health of our children and other future generations. Most importantly, the time scale and irreversible nature of the impacts of these toxic substances on species throughout the ecosystem are such that it may be difficult, if not impossible, to correct the problems once they are detected, measured and understood. These issues point to the need for holistic and sustainable approaches to deal with present and future pollution problems for the Great Lakes Basin Ecosystem.

Creating a Sustainable Environment for the Great Lakes

By the year 2020, the status of water quality in the Great Lakes could present an entirely different scenario. By applying the ecosystem approach and the concept of sustainable development to environmental restoration and protection now, we are committing ourselves to take "ownership" of our own future. Each of us must be willing to consider our own lifestyles -- as well as the environmental and economic practices of our communities, our provinces, states and our nations -- and how our actions must change to ensure that the future is one that sustains and protects our natural resources and our economic growth. Unless the Great Lakes region is prepared for the future, greater environmental problems and major cost impacts cannot be prevented, and the goal of zero discharge of pesistent toxic substances into the lakes will be a forgotten dream.

Conclusions

Several obstacles have traditionally prevented the Great Lakes from being incorporated into the region's formal educational structure. Few materials were produced on the Great Lakes, and those that were tended to focus on one section of the lakes and were distributed to a small segment of the educational community. Teachers themselves were rarely educated about the lakes, and a coordinated effort to promote Great Lakes education throughout the basin has been lacking.

To encourage and support the development and use of Great Lakes curricula in the region, the Commission has created a multi-faceted binational program. Results of a survey sent to several hundred educators and producers of educational resources led to the production of the Directory of Great Lakes Education Material, distributed thus far to over 40,000 educators in the region. The publication, available free of charge, includes listings of teacher resources and curricula to teach about the Great Lakes and environmental issues in a variety of subjects and grade levels.

A binational Education Advisory Council also was established to ensure that educators gain the awareness and confidence to teach others about the lakes. Teacher training workshops held throughout the region by the Council, as well as a week-long summer institute, provide indepth experiences in Great Lakes and environmental education. Research is ongoing to design a clearinghouse for Great Lakes education, and the Council is working with other organizations and agencies to ensure that the Great Lakes are incorporated into mandated curriculum objectives in the region's eight states and two provinces. The Commision also held a live-by-satellite television conference to provide the opportunity for teachers and community leaders to share information about innovative programs and curricula developed in the region.

When we consider our daily actions and how little effort it takes to change our behaviours to reflect the value we place on a clean environment, we should also recognize that all of these actions have a positive impact on the health of our HOMES (Huron, Ontario, Michigan, Erie and Superior) and to Canada and the United States. We must work individually and collectively to ensure our two nations honour their commitment to the Agreement and to the future of the next generation.

WATER EDUCATORS FOR PUBLIC AWARENESS

John Kaliszewski[1]
Barbara Preskorn[2]
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ABSTRACT

Agreement exists that much more can and should be done to educate Coloradans regarding water matters. What has been done successfully is a small fraction of what might be done for water resources education of children, teens, and adults. Before the general citizenry can engage in discussion and deliberation regarding intrastate, interstate, and international water matters, they need ample and multiple opportunities to receive educational programming and materials.

<u>Overview</u>

Educational programming satisfies the basic need for communication. Better communication of facts regarding the public's cultural value of water, water resource matters, and ideas regarding water management techniques would allow for frequent citizen participation and inclusion in decision-making processes.

Since water is essential to all life, and water is the life blood of Colorado, it is our most valued resource. It cannot be considered as a special interest, nor should scientific, social, and managerial facts regarding water be left up to the individual to research, make sense of, and to discuss intelligently without the aid of organized and group interaction. Public school and lower division classes, seminars, workshops, forums, and public news media are logical places where statewide coordinated water resources education could occur with regularity.

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NEED FOR EDUCATIONAL PROGRAMMING

Educational coordination through a "master blueprint" is needed when outlining the public's educational needs. Water issues have been dealt with locally and sporadically in terms of audiences reached. The typical audience member at public meetings regarding water matters generally have vested interests or principles and already have some working knowledge of water law and policy. Unfortunately, these individuals represent a small proportion of the state's population.

With coming changes in water management and in public values about the uses of water, much more is needed to prepare citizens for the future. We are the largest population to ever inhabit Colorado as well as being a population extremely dependant upon water for livelihoods, recreation, and agriculture--so much so that all available water is now over-allocated. Water right holders and users are more plentiful than water, so when severe drought hits our ever increasing population, the chances are slim that all water right holders would receive anything close to their allocation. Those first in line receive all their share, resulting in many going without any at all. This would bring about a traumatic lesson for those unaware of Colorado water law. Education and communication today could ease trauma for the majority later when the competition for water may become even more dramatic than it is today.

Collectively, individuals and groups involved in water resource education need to define a formal and effective process for acquainting the majority of citizens with, at least, rudimentary awareness of water law and management policies. Citizens who want more detailed information should have easy access to materials prepared for the general reader and have interactive opportunities to discuss, learn, and form an educated opinion about the value of water and it's management.

Public libraries could be a tremendous resource in making information readily available. Librarians could feature displays and special gatherings highlighting authors, specific books, and audio-visual materials. In order to achieve coordinated efforts with other educational events, librarians and museum staff members would need training regarding overall goals and how to keep these efforts sustained.

This paper does not purport to be definitive of all the fine efforts that have been and are being undertaken to increase public awareness regarding water, but focuses instead on what the authors feel will be needed to adequately address water needs into the next century. History is certainly a part of this envisioned educational format. But some dramatic changes will be forthcoming in how educators, politicians, and managers of water agencies and businesses view water resource education.

A variety of water related programming currently serve these needs both in Colorado and in other Western and Mid-Western states. Yet they remain uncoordinated and to a larger degree, unaware of the methodology and educational prototypes important to achieve goals specified in efforts where inclusive information would be refined into a bona-fide coordinated curriculum effort.

Current Programming

Some of the effective programs have served Colorado's water education needs. They include the public schools where emphasis is placed on environmental and physical science relationships to water. The Colorado Water Congress sponsors public meetings statewide related to specific water projects and specified goals of those in the water management and development community. The Denver Water Board and the City of Aurora both promote educational and conservation programming for youth and the general public. The City of Aurora utilizes public access cable TV channels to promote water issues.

The Colorado Division of Water Resources sponsored a water educational exhibit at the 1990 Colorado State Fair. Central Colorado Water Conservancy District sponsors *Water News* and water festivals for youth. Western State College holds the Colorado Water Workshop annually, but generally, only a few water management novices attend this event. A Colorado Water Education Foundation is being established to provide such written materials as a Colorado Water Atlas and water educational program activities.

Eight one-day public meetings were held around the state during 1990 regarding the future of water resources. These meetings "Colorado Water: The Next 100 Years" were sponsored by Front Range Community College and the Colorado Endowment for the Humanities. *The Colorado Citizens' Water Law Handbook* was prepared specifically for this series of programs.[4] In July 1992, the Denver

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[4] This handbook available through Colorado State University, George Vranesh, Information Series #67.

Museum of Natural History conducted the Cultural and Ecological Institute on Water conference.

These programs reach a local audience or participants for a limited time. These contributions are significant and could serve as the building blocks for a much larger effort addressing statewide water educational needs.

Determining How Much the Public Knows About Water

A significant survey conducted addressing this question was at the "Colorado Water: Liquid Gold" exhibit, coordinated by the Colorado Division of Water Resources, involving over forty Colorado water organizations at the 1990 Colorado State Fair. Of the 7,400 respondents to this survey, 83% were from Colorado, and about one/half had previously gone through the exhibit.

Low scores on relatively simple questions stimulated concern that the public does not have basic information regarding Colorado water issues, even when answers to all the questions were demonstrated in the exhibits. Survey results indicated that a very significant percentage of the Colorado public is either unfamiliar with or is misinformed about Colorado water, resulting in disproportionate misperceptions.

For example, only 15% of the respondents knew correctly that 88% of Colorado's water is consumed by agriculture. The fact that 57% of the respondents believe that agriculture consumes 40% or less of the water consumed in Colorado indicates that the majority of the public does not know which water user group is the largest consumer of water in the state.

A second example highlights common misperceptions Coloradans have about water facts. Relative to the percent of water consumed by residents of the Denver metropolitan area, only 2% of the respondents chose the correct answer. The fact that 59% of the respondents believed that one-third of all water consumed in Colorado is consumed in the Denver metropolitan area emphasizes the misperception that the public has about urban areas consuming an inordinate amount of water. In fact, the Denver area consumes only 3% of the state's water. Furthermore, the public found certain terminology confusing; i.e., distinctions between water use and water consumption.

An Informed Public is an Essential Component in Future Planning and Development of Colorado Water Resources

Survey results indicate that the public is interested in being more informed in this area and believe that the education system should take an increasing active role in educating the public relative to water resources.

CENTRAL COORDINATING AGENCY

A central office could effectively address statewide needs and activities. Such an agency could be either incorporated into existing programs within the Colorado Department of Education, the Colorado Department of Higher Education, or the Colorado Department of Natural Resources, or established separately by non-governmental water interested agencies. A combination of efforts by participating governmental departments is another possibility.

The goal of such programs would be education, therefore, it would seem apparent that educators in the Colorado Department of Education and the Colorado Department of Higher Education should take a leadership role. Technical assistance could be provided by the Colorado Department of Natural Resources and other Colorado water management and water interest groups. Development of a statewide water resources education program should be done under a central coordinating agency.

Approaches to be Considered Toward Educating the Public on Water

There are five basic approaches that can be utilized:

1. Incorporate water resources education into school curriculum both at the public level and at the undergraduate college level
2. Newsletters and other written materials
3. Exhibits and lectures
4. Seminars, workshops, and forums
5. Utilize the media

In order for any of these approaches to be successful, careful stock must be taken of the public's value of water, as well as of the public's priorities in relation to future development and uses of Colorado water.

Statewide Consortium

To prepare the majority of citizens for the coming times a consortium of effort on the part of interested educators and agencies already involved will be necessary.[5] Conducting public hearings and town hall meetings would be advantageous to the statewide approach to water resources education and to analyze resistances to achieving broad publicly stated goals.

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[5] Please see example in handout entitled Consortium of Colorado Water Resource Educators

EDUCATIONAL METHODOLOGIES

Preliminary to educational materials and formats, teacher preparation and curriculum presentation need to be considered. Teachers should be able to enhance their ability to teach water resource curriculum through credit courses at summer workshops. Non-credit and undergraduate courses should be available to adults through continuing education programs, regardless of the student's location. Approaches could be via satellite and, on occasion, op tel courses. State government could sponsor a exchange network whereby citizens could visit sites where water dilemmas are much different than their own. This networking would enhance the general public's appreciation for understanding statewide water issues.

The public's need to be educated in areas of water law, water management history, and water engineering, as well as the economic, political, and cultural values of water are most important considerations in developing this curriculum and educational programming.

FISCAL COSTS OF WATER RESOURCES EDUCATION

Sufficient federal, state, and private funds would be needed to insure an effect program. Public schools and higher education could incorporate some of this need in routine curricular changes, if goals were established and defined.

Reasonably, a project of this magnitude could take a minimum of five years to initiate and establish programming activities that would be coordinated through a central agency. Pertinent data collection would be a integral part of this programming.

Funding resources needed for such a project would be generated from a multitude of private, community, and governmental sources. This effort would also attract representatives from the respective funding sources that this effort would be targeted toward. These representatives could be an additional resource to public relations and for further promotional activities.

SESSION VI-A

EDUCATION IN WATER RESOURCES AND ENVIRONMENT

A NOVEL PROGRAM FOR THE MASTER'S DEGREE
IN HYDRAULIC ENGINEERING IN THE UNIVERSIDAD
AUTONOMA DE SAN LUIS POTOSI

Daniel Fco. Campos-Aranda[1]
Arturo Difurt-Candelaria[2]

1. INTRODUCTION.

The College of Engineering of the Universidad Autónoma de San Luis Potosí with the Secretaría de Agricultura y Recursos Hidráulicos (SARH), created in 1980 a speciality in Water Resources Planning. As a result, only two classes with thirty four graduates came out. That above program evolved to the actual master's degree in Hydraulic Engineering, which began in 1982 and so far seven classes with a total of ninety six students have finished the course load. They were from different backgrounds, mainly civil and geology, as it is shown in detail in Table 1.

The master's degree program in Hydraulic Engineering was oriented in general to the design of hydraulic structures with two main objectives: first, capacitation of engineers, faculty and researchers within the speciality and related topics in hydraulic and water resources. Second, to provide extension courses oriented to the actualization of engineers in the government and private companies.

The program was given in three semesters, with the curriculum as it is shown in Table 2. In addition, it was included one or two seminars in each semester, with variable length from eight to forty hours, with selected topics in hydrometry, geophysics, water law, agrometeorology and geochemistry.

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Class	Years	Enrollment	Background: Civil = C Geology = G Others = O	Students who finish course load	Graduates
1st.	1982-1983	22	C = 20 G = 1 O = 1	6	0
2nd.	1983-1985	31	C = 18 G = 13	10	0
3rd.	1984-1986	11	C = 5 G = 6	3	0
4th.	1985-1987	6	C = 4 G = 2	2	1
5th.	1986-1988	13	C = 12 G = 1	3	0
6th.	1988-1989	7	C = 6 G = 1	1	0
7th.	1989-1991	6	C = 2 G = 1 O = 3	3	0
-	Totals	96	-	28	1

Table 1. General characteristics of the students in the program.

First Semester:	Second Semester:	Third Semester:
• Mathematics. • Numerical Methods. • Fluid Mechanics. • Surface Hydrology	• Open Channel Flow. • Geohydrology I. • Hydraulic Infrastructures. • Water Supply and Sewerage.	• Introduction to Modeling. • Geohydrology II. • Water Resources Planning. • Irrigation and Drainage Systems.

Table 2. Curriculum of actual master's degree program.

2. A NEW PROGRAM.

With the foundation of the Comisión Nacional del Agua (CNA) inside the SARH in 1987, and the establishment of the Programa Nacional de Agua Potable y Alcantarillado in may of 1990, an urgent necessity of having specialist in the area of environmental pollution, led to the necessity of a reorientation of the courses given in the master's degree in Hydraulic Engineering, that will include the above topics. For the above reason, the program has been change as it is shown in Table 3.

First Semester:	Second Semester:	Third Semester:
• Mathematics and Numerical Methods. • Fluid Mechanics. • Chemistry and Ecology. • Surface Hydrology.	• Advanced Hydraulics. • Geohydrology. • Water Contamination. • Water Supply and Sewerage.	• Hydraulic Infrastructures. • Water Treatment System. • Water Resources Planning. • Environmental Pollution.

Table 3. Curriculum of the propose program.

In the last column of Table 1, it can be noticed that a limited number of students have obtained the degree; therefore, it has been consider in the new program an additional semester for the master's thesis, which will be directed by a faculty within his research topics.

3. DESCRIPTION OF THE NEW PROGRAM.

Each semester has eighteen weeks, with four lectures per subject per week; that is, seventy two hours per subject. A description of the subjects is now given [1, 2].

Mathematics and Numerical Methods. Fourier series, Laplace transform, linear algebra and matrices, complex variables, vector analysis, solution of non-linear equations, numerical differentiation and integration, ordinary differential equations, methods for solving linear systems, solution to partial-differential equations.

Fluid Mechanics. Fundamental equations, elements of potential flow theory, turbulent flows, boundary layers, jets and cavities, diffusion and dispersion.

Chemistry and Ecology. Physical and chemical properties of water, substances found in water, diseases caused by bacteria and other organisms, standards for drinking-water and bacterial purity, biosphere and ecosystems, energy fluxes, biological equilibrium.

Surface Hydrology. Hydrological cycle processes, hydrological design of infrastructure, estimation and control of maximum floods, introduction to modeling, urban stormwater management.

Advanced Hydraulics. Open channel flow, waterhammer analysis. surge tanks, pipe flow analysis and networks.

Geohydrology. Groundwater and aquifers, Darcy law and hydraulic properties, well-flow systems, groundwater exploration, evaluation and exploitation, geologic processes and modeling.

Water Contamination. Characterization of waste waters, neutralization of waters, river contamination, groundwater contamination, industrial waste waters, agricultural waste waters.

Water Supply and Sewerage. Estimation of yield, design works to procure water, water treatment methods, design of distributions systems, design of sewerage systems, operation and conservation.

Hydraulic Infrastructures. Dams and diversions works, spillways, outlet works, irrigations systems, agricultural drainage systems, maintenance and operation.

Water Treatment Systems. Quality of water, type and capacity of plant, clarification-flocculation and filtration, corrective treatments, disinfection.

Water Resources Planning. Objectives and methods of evaluation of water management plans, managing surface water quantity, water quality management, combined use of surface and groundwater resources.

Environmental Pollution. Atmospheric contamination, trash and solid residues, combustion and incineration control, soil contamination control, noise reduction.

On the other hand, a set of seminars will be given, two each semester. There are listed with ten hours of length each.

First Semester:
S1. **Water Laws: Analysis and Propositions.**
S2. **Diagnostic about the Water Supply and Sewerage in Cities.**

Second Semester:
S3 **Management and Operation of Water Supply and Sewerage Systems.**
S4. **Environmental Impact of the Hydraulic Infrastructure.**

Third Semester:
S5. **Use of Waste Water.**
S6. **Social aspects in Communities.**

4. FINAL REMARKS.

Water resources in the country have conditioned the development of certain areas; in that sense, zones with sufficient resources have the option to raise their economic level. Moreover, an efficient planning of the hydraulics resources will give optimum results. At present time, there is an inefficient planning in the use of water in the city of San Luis Potosí, as well as in the state no only in surface water but also in groundwater resources. In other hand, the quality of water is being diminish, mainly by manufacture industry (90%), domestic uses (9.5%) and extractive industry (0.5%), according to a CNA report.

For the above reasons, the propose program includes: Chemistry and Ecology, Water Contamination, Environmental Pollution and Water Treatment Systems, as new subjects. Moreover, six seminaries treat in some detail topics in legal, social and operative aspects of the use of water and its deterioration. These will be the challenges of the new engineer [3,4].

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EXPERIENTIAL LEARNING IN HYDROLOGY AT COLORADO MOUNTAIN COLLEGE

Peter Jeschofnig[1]

In 1987, Colorado Mountain College's Timberline Campus in Leadville (CMC) added a Water Quality Option to its existing Environmental Technology (E.T.) Program. This option was specifically designed to train students as environmental technicians in hydrology and water quality for employment by government agencies and private environmental firms.

Situated in the heart of the Rocky Mountains at 10,000+ foot elevation, CMC-Timberline is the highest college campus in North America and in an unique environmental area. The city of Leadville and Timberline campus are close to the headwaters of the Arkansas river. Leadville is well-known as a historic mining town, as is evidenced by the numerous old mine head frames around town and the abundant mine tailings. Due to its mining history and geologic misfortune that pyrite-containing ore is likely to produce acid-mine drainage, Leadville's California Gulch has been named a Superfund site and is on the National Priorities List.

Mining activities in the Leadville area began with placer mining of gold-bearing deposits along California Gulch in 1859. The placer deposits were quickly exhausted and underground mining of some lode veins in the upper California Gulch area began. Silver-laden lead carbonate ore was discovered in the area, and silver mining began in 1875. A number of mills and smelters were built to process the mined ore, and the town expanded considerably. Underground mining was extensive, and mine drainage tunnels were built as a way to dewater these workings. Construction of the Yak Tunnel began in 1889, and over a number of years was extended to its present length of approximately 4 miles. Current mining activity is limted primarily to the Black Cloud Mine in Iowa Gulch, and several other small mining ventures. Total metal production from the Leadville District from 1859 through 1966 totaled about 24 million tons, valued at around $ 500 million. The principal metals were silver, zinc, lead, gold, and copper.

Acid-mine drainage, the major problem of the California Gulch superfund site is produced when sulfide ores are exposed to an oxidizing environment, such as the atmosphere or oxygenated water and become unstable. Pyrite is an important mineral in this process because it is commonly associated with ore

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desposits and when oxidized will form sulfuric acid and acidic water. The decrease in pH causes an increase in the solubility of minerals containing heavy metals such as zinc, cadmium, lead, arsenic, etc. thereby increasing the metals' mobility and increasing the concentration of those metals in the water. Through this process large quantities of heavy metals are dissolved and carried via California Gulch into the Arkansas river. The Leadville drainage tunnel, which drains numerous mines north of Leadville, and discharges to the East Fork of the Arkansas (north of Leadville) has had a similar history and has also added large quantities of heavy metals to the Arkansas river upstream from Leadville. The East Fork joins Tennessee Creek downstream from the Leadville Tunnel discharge to form the Arkansas River.

The water quality in the Arkansas River is adversely affected by the contributions of metals, acid, and contaminated sediments from both the Leadville Tunnel and California Gulch from their respective confluence with the Arkansas River at least to the confluence with Lake Creek (Wentz, 1974). Although this acid mine drainage condition is a major environmental problem for Lake county and downstream Chaffee county residents and a financial headache for the parties responsible for clean-up (Asarco et al have spent over $ 46 million to date and the project-end nowhere in sight), it is an ideal natural laboratory for our students studying water quality and environmental restoration procedures.

The E.T. program includes a solid mix of basic academic courses taken during the first year, as well as program specific environmental courses, generally taken during the second year. Typical first year courses include College Biology, College Chemistry, English Composition and Technical Writing, Introductory Soils, Computer Applications, Algebra or Statistics, and Surface Water hydrology. Second year courses in the water quality option include introduction to natural history, aquatic biology, groundwater hydrology, water and waste water treatment, soil and water chemistry, environmental law, QA/QC, air quality control and monitoring, hazardous and non-hazardous waste management, and speech. However, the most exciting aspects of the program are its practical, hands-on components in the lab and in the field.

Numerous class trips and various field projects are conducted throughout the school year. Additionally, all E.T. students are required to initiate and complete a summer practicum in the environmental field between their first and second year of study.

Although it has been demonstrated that laboratory and field experience as part of a class is important in introducing students to basic hands-on lab and field techniques, these lab and field session are not enough to build competency in methodology nor in the use of essential equipment. Internship or coop work experience is designed to amplify and enhance the use of methods and instrumentation learned in the classroom, laboratory and field settings, and is also essential in preparing students for the job market. Yet, despite the efforts of faculty to ensure a well-balanced exposure to a variety of job-skills for students during their summer coop work experience, the results are often so varied that students may not have received all the anticipated skills or skill reinforcement from their coop experience.

As a result of these above shortcomings of lab and field exercises and the coop work experience, the practical elements of the ET program have been further expanded with the recent implementation of a new continuous and comprehensive field project involving local stream environments. The project is introduced to new students in their first year "Surface Water Hydrology" class. These students are then paired with second year students (who have been part of the field project for the previous year) and assigned stream segments from which they will take various measurements, collect samples, perform analyses and properly record field observations throughout their entire two year program.

First Year:
During the first-year hydrology class, the field project starts out with several field orientation sessions, during which students are familiarized with the general setting, basic observation skills, introduction to field note taking, and basic field techniques to get them starting with their project. Initially, they are expected to estimate the cross-sectional area at a couple of places along their stream segment, and later to actually measure a cross-sectional profile as well. They learn how to use a current meter and various techniques for the estimation of velocity, and calculate stream discharge. If USGS data is available, either in published form or through "Water Talk" recodings, students are expected to check their calculations against such existing information. If weirs or Parshall flumes exist on their segment, students are expected to compare weir discharge rates with those determined through the area-velocity method.

As the semester progresses, students continue with their previous measurements and start additional observations as the learn the appropriate theoretical background in the classroom. A few weeks into the semester, they start taking chemical measurements in the field and collect grab and composite samples, both filtered (.45 um) and unfiltered for analysis in the laboratory. The initial field readings are simple ones, like water temperature, pH, pE, and dissolved oxygen, while beginning lab analyses include alkalinity and hardness titrations, suspended solids, turbidity, conductivity, pH, redox potential. During the long Leadville winters, snow surveys are taken as well, and the appropriate results like snow depth, density, water content, etc. recorded. As we are fortunate to have a computerized weather station on campus, interested students may supplement their field observation with weather data from that station.

In the laboratory, students are also introduced to proper laboratory techniques and quality assurance/quality control (QA/QC) procedures. Ancilliary to and in preparation for field observations and data collection, they are trained to get into the habit of acid washing their collection bottles. QA/QC duplicates are collected and sample blanks prepared on a rountine basis and occasionally a faculty member will supply a standard or blank to queck on students' lab accuracy and precision.

In addition to keeping a field/lab notebook, students are encouraged to input their data into a database/spreadsheet on a regular basis and plot various graphs for required reports.

<u>Second Year:</u>
During the second year, when students are introduced to Atomic Absorption analysis (both flame and carbon furnace) and gas chromatography in a soil and water chemistry course, they will analyze their water and/or soil samples for specific heavy metals (AA) and selected organics (GC) in addition to their regular, more basic measurement which they continue from the previous year. Besides AA analyses, use of wet chemistry kits such as Hach or LaMotte are taught as well. Occasionally, second-year students will perform AA analyses for first-year students. As samples are passed from one student to another, or occasionally to a commcercial lab or DOW lab for heavy metals analysis, chain-of-custody procedures are followed with the appropriate paper work to be completed by all students.

In all second year environmental classes, students receive assignments related to the monitoring of their steam segment, and a portion of every grade reflects their performance in this project. As part of such classes, students are expected to monitor streambank conditions (erosion), analyze soil type, basic vegetation, etc. In the bioassay/aquatic biology class and water treatment classes where students learn to determine BOD, fecal coliform analyses, etc.

they will also run these newly learned procedures on samples from their stream section. During the bioassay component of aquatic biology class, benthic diversity as an indicator of water quality becomes a part of the study. Macroinvertebrates are collected and analyzed as to species composition, functional feeding groups, diversity index, etc. The results are interpreted as to the deterioration or improvement of the aquatic ecosystem.

Whenever DOW biologists visit the area, students accompany them and observe and record the results of fish population and biomass studies. Visits by other environmental experts are arranged periodically to provide additional input and ideas to the field projects.

Students who are not as academically minded or talented as others have benefitted especially from the project. In the past, a number of students struggled through hydrology with very little enthusiasm for the subject matter. The field project has increased the enthusiasm of these students and they frequently make up their deficiencies in the class room by an extra effort in the field. If for nothing else, but this aspect alone, the field project is worthwhile and can be considered a success. It is also hoped that this project will reduce the drop-out rate from this quite demanding program.

The USGS has hired CMC students as observers/samplers for several years, and USGS supervisors have commented that the students who have participated in this field project seem to exhibit greater self-confidence and their improved expertise is very apparent.

In summary, this ongoing experiential learning project produces meaningful environmental data while reinforcing student enthusiasm, developing student self-confidence and providing essential experiences in field research and documentation. After two years in the project, graduates are authorities on their stream segment and posses the type of knowledge, skills and experiences desired by employers in the environmental field.

The Colorado Commission on Higher Education Water Resources Program of Excellence at Colorado State University

Laurel Saito[1]

ABSTRACT

In 1990, the Colorado Commission on Higher Education (CCHE) designated Colorado State University's Water Resources Program as a *Program of Excellence*. During the first year of the program, a number of activities were successfully accomplished. These activities included an undergraduate scholarship program, a summer scholars program, the awarding of several graduate assistantships, a minority institutions collaboration program, educational enhancements, and faculty support. This paper presents details of these accomplishments as well as a discussion of program plans for the future.

INTRODUCTION

The Colorado Commission on Higher Education (CCHE) was established in 1965 by the state legislature to improve the availability, quality, and efficiency of higher education in Colorado, as well as to plan for future post-secondary educational development. CCHE is considered the central coordinating agency for the state and local higher education institutions in Colorado and provides guidance to these institutions regarding academic programs and educational policies.

To promote excellence throughout post-secondary education in Colorado, the state legislature established the *Programs of Excellence* competition in 1988. Each year CCHE selects higher education programs which will be eligible to receive special funding from the legislature to promote the programs. Selection criteria include the quality of the educational experience offered, the accomplishments of students and faculty involved with the programs, and the contributions of the programs to the state of Colorado. For 1990-91, CCHE designated five programs as *Programs of Excellence* which could collectively receive up to $3.5 million through 1994. One of the programs selected by CCHE is Colorado State University's Water Resources Program, which will receive $750,000 during the three-year award period. This presentation discusses the goals and accomplishments of this *Program of Excellence* during its first year.

PROPOSED PROGRAM

In September 1990, the College of Engineering at Colorado State University (CSU) nominated the water resources programs in the Departments of Civil Engineering and

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Agricultural and Chemical Engineering for designation as a *Program of Excellence*. The proposal highlighted the outstanding quality and achievements of these programs and requested funding of almost $2 million over a five-year period to enhance CSU's water resources activities through a student support and diversity program, an educational enhancement program, and a faculty support program.

Student support and diversity program

The majority of the requested funds were to be applied to the student support and diversity program. This program was directed towards increasing opportunities for Colorado students and minority and women students and consisted of five components. The first involved the creation of undergraduate scholarships for Colorado citizens, women, and minorities. Scholarship recipients would take a special options program which would emphasize water resources, thereby encouraging their interest in the area.

A second element of the student support and diversity program was an extension of the existing CSU summer scholars program. This program would provide for internships for undergraduate students that would allow them to work with faculty on research specifically related to water and environmental resources. Also directed towards Colorado residents, women, and minorities, the program would promote interest in graduate school and academic careers.

In addition to undergraduate assistance, the student support and diversity program would involve the awarding of graduate assistantships for Colorado residents, women, and minorities. Students completing the summer scholars program would be high priority candidates for the assistantships.

The student support and diversity program also included the establishment of a minority institutions cooperative program in water and environmental resources education and research through a summer workshop which would seek to develop agreements between Historically Black Colleges and Universities (HBCUs), federal agencies, and CSU. The intentions of the program would be to attract African-American students to CSU to study water and environmental resources.

The implementation of a women students recruitment and advisory program designed to encourage women students to enter water and environmental resources studies at CSU was the fifth component of the student support and diversity program. This program included the organization of a panel of female leaders in the water and environmental fields that would advise and assist in the recruitment of women students.

Educational enhancement program

Elements of the educational enhancement program would strengthen undergraduate instruction in water and environmental resources. To modernize the instructional technologies available, an educational technologies program would facilitate the installation of computer-aided instruction in special classrooms. In addition, the acquisition of water resources information in CD-ROM formats and the augmentation of equipment for a water resources instructional laboratory would be accomplished through the educational enhancement program. The program would also feature an undergraduate seminar program which would bring five water leaders to CSU to give seminars and meet with students.

Faculty support program

The faculty support program would assist new and continuing faculty with travel, laboratory equipment, and computer expenditures.

FIRST YEAR PROGRAM ACCOMPLISHMENTS

Although the proposal requested funds of approximately $400,000 each year for five years, the actual amount approved by CCHE for the Water Resources Program of Excellence was $250,000 per year for three years. CSU was given the freedom to spend these reduced funds on any of the activities mentioned in the proposal. Consequently, the activities of the *Program of Excellence* were not as ambitious as originally planned, but nevertheless, much was accomplished during the first year.

Student support and diversity program

The undergraduate scholarship program was highly successful and is discussed in greater detail later. A total of thirteen scholarships were awarded, including seven to female students, and one to a hispanic student. The author, a female graduate student in water resources engineering, served as coordinator and mentor for the scholarship recipients.

Five summer scholar internships have been awarded for the summer of 1992 with *Program of Excellence* funds. Each of the students will work for ten weeks with one or more faculty members in ongoing research related to water and environmental resources. The students receive stipends of $2500 and give oral presentations on their work at the end of the summer. The research is continued during the school year although the students do not receive any further financial support. They receive two units of Independent Course studies credit each semester which is applicable towards technical electives and prepare a final written and oral report in May 1993. Research topics for the summer scholars include: plant synthesis of small organic sediments, sediment gully erosion, computerized expert systems to handle decision-making in water resources management, the impact of irrigation water use on water quality, and the mapping of Navajo agriculture products industries farmlands using global positioning and geographic information systems.

Nine full or partial graduate assistantships have been awarded. Two assistantships were granted in the Agricultural and Chemical Engineering Department to female graduate students studying water resources. One student is conducting field studies in the San Luis Valley of Colorado to determine if simple methods can be used to predict the quality of shallow ground water and estimate the quality of nitrate leaching from the soil. The other student is evaluating the impacts of current irrigating practices on surface and ground water due to nitrate and pesticide leaching for the Central Colorado Water Conservancy District. The remaining assistantships have been awarded to Civil Engineering graduate students. Research being done by these students include assessing the impacts of global climate change on irrigated and non-irrigated agriculture in Colorado; a microcomputer-based advisory system for irrigated agriculture in the Brighton area of Colorado which will integrate geographic information systems with a dynamic water resources model; investigations into gully formation for waste impoundment; computer modeling of irrigation distribution systems; finite element modeling of the migration of contaminant flumes in the ground water at the Rocky Mountain Arsenal; an investigation of interbasin transfer issues; and an assessment of the use of models in water resources.

The minority institutions collaboration program has gotten off to a very good start. CSU has been actively pursuing the establishment of this program for a several years after recognizing the potential for augmenting its predominantly nonminority graduate programs with recent graduates from Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs) that have limited graduate programs. The additional support received from CCHE and the Ford Foundation has resulted in this conference, *Water Resources and Environment: Education, Training and Research*, and CSU's contacts with a number of minority institutions led to a planning meeting in May 1992 at Virginia State University to assess the feasibility of creating a consortium of HBCUs and MIs in the area of water resources and environmental management. A number of agencies attended this meeting and expressed their support of the consortium, including the U.S. Departments of Agriculture, Defense, Energy, and the Interior, the U.S. Agency for International Development, the U.S. Environmental Protection Agency, and the National Association for Equal Opportunity in Higher Education.

To encourage women students to enter the water and environmental fields, seven undergraduate scholarships and three graduate assistantships were awarded to women with funds from the *Program of Excellence*. Ongoing women recruitment programs at CSU have also received support, including the special RAM JETS (Junior Engineering Technical Society) session in November 1991 in which 47 female students from seven local high schools participated in hands-on engineering activities. These activities included a water filtration exhibit in the fluid mechanics laboratory at CSU.

Educational enhancement program and faculty support program

Faculty and student participation in the *Colorado Water Engineering and Management Conference* held during Spring Semester 1992 was financed with funds from the *Program* *of Excellence*. This two-day conference featured presentations covering environmental and water resources issues and was videotaped for distribution to other state institutions. In addition, the conference included a distinguished lecture by Dr. Vujica Yevjevich on "Water Resources and Civilization," which was funded by the *Program of Excellence*.

Faculty were also sponsored to attend CSU's annual *Hydrology Days*, a conference featuring student and professional presentations on a variety of topics in hydrology. Other funds were used to finance travel and conference fees for faculty invited to give keynote addresses on topics related to water and environmental resources.

Program of Excellence funds enhanced educational technologies by allowing the acquisition of computers, software, and laboratory equipment. Computers and software purchased were used for research into the two-dimensional movement of immiscible fluids in ground water and the development of graphical displays for decision support in complex water resources systems. A fluorometer, ion exchange demonstration unit, dissolved oxygen meters, pH meters, and a spectrophotometer were some of the laboratory equipment obtained to benefit both water quality lab courses and research activities. In addition, the *Program of Excellence* financed the relocation of a flume from the Engineering Research Center to the thermal fluid sciences lab on the main campus.

UNDERGRADUATE SCHOLARSHIP PROGRAM

As mentioned earlier, thirteen undergraduate scholarships were awarded for the 1991-92 academic year to outstanding students in engineering. The recipients included two students from Engineering Science, two from Agricultural Engineering, and nine from Civil Engineering. Three students were sophomores, four were juniors, and the remainder were seniors. The students were selected based on their academic and extracurricular achievements, with special attention paid to Colorado residents, women, and minorities. Three students received scholarships of $5000 and ten received $2500, making these the most prestigious undergraduate scholarships offered in the College of Engineering.

The goals of the scholarship program were to introduce the students to water resources and the outstanding program at CSU, and encourage them to pursue careers in water and environmental resources. Consequently, the students were required to participate in activities throughout each semester which exposed them to water resources concepts and issues. A graduate student funded partially by the *Program of Excellence* was designated as the scholarship program coordinator and was responsible for organizing these activities.

During the fall semester, scholarship recipients participated in three seminars, and each prepared a paper on a topic in water resources. The first seminar featured the *Denver Metro Water Game*, a computerized spreadsheet gaming simulation of the Denver metro area water supply developed by the University of Colorado at Denver. To play the game, the students broke up into decision-making groups and attempted to manage urban water supplies by selecting water projects and conservation measures at ten-year intervals during the 50-year simulation. Project considerations during the game included environmental mitigation, capital costs, ease of implementation, and reliability. This exercise introduced students to the complexities of water management as well as familiarized them with actual projects considered for the Denver metro area.

Dr. Neil Grigg, the newly-appointed Civil Engineering Department Head, spoke to the students during the second seminar. With a distinguished career in the field of water resources engineering and management, Dr. Grigg offered the students insights into current important issues in water resources and the need for their expertise in addressing and resolving some of these issues.

For the third seminar, the students selected an on-campus seminar or conference of their choice. At least six hour-long seminar series are offered at CSU each semester with sessions pertaining to water resources, and students were given schedules for these series and were asked to attend one session and write a one-page paper about it. Seminar topics chosen by the students ranged from removing volatile organics from ground water to evaluating modeling strategies for a complex water resource system. In lieu of attending an on-campus seminar, some students chose to attend and review the Fort Collins Water Symposium.

Each student also prepared a paper which highlighted an aspect of water resources that interested them. To give students some direction, it was suggested that they research one of the projects included in the *Denver Metro Water Game*. Paper topics selected by the students included: ground water development in the Denver Basin; the Estabrook Reservoir; the Windy Gap Project; Colorado River conflicts; Thornton's Northern Project; Two Forks Reservoir; the Green Mountain Exchange Project; nonpotable reuse; the Colorado-Big Thompson Project; the Williams Fork gravity collection system; and Denver's potable reuse demonstration plant.

Spring semester activities included two hour-long seminars, a field trip, and the completion of a display on the Colorado River System for the *Children's Water Festival* held in Fort Collins in May. Dr. John Eckhardt of the Colorado State Engineer's Office (SEO) spoke to the students about the Colorado River System during the first seminar early in the semester. Drawing upon his experience with the Northern Colorado Water Conservancy District, the Imperial Irrigation District in California, and the SEO, Dr. Eckhardt introduced the students to a number of management concerns in the Colorado River Basin.

The second seminar focussed on career options for engineers in water resources and featured a panel of three professional engineers. Ms. Julie Kraus of the Colorado State Engineer's Office spoke to the students about water resources careers in the public sector, while Mr. Mark Peterson of Resource Consultants and Engineers in Fort Collins gave the students a perspective of private sector work. Dr. Neil Grigg of CSU rounded out the session with a brief discussion on academic careers in water resources.

Instead of a third seminar, the thirteen scholarship students participated in a day-long field trip to Nebraska led by Dr. Morris Skinner of CSU's Civil Engineering Department. The trip featured guided tours of Kingsley Dam and its hydroelectric facilities, an inverted siphon, and a coal-fired steam generating plant.

The final project of the scholarship program for the 1991-92 academic year was the preparation of a display on the Colorado River system for the *Fort Collins Children's Water Festival*. Drawing from the introduction given by Dr. Eckhardt in the first seminar, each student chose a topic of interest surrounding the Colorado River Basin and prepared a small display board which would be understandable to the fourth and fifth graders attending the festival. Topics selected by the students included salinity, hydropower, the Central Arizona Project, ground water seepage, water rights, Mexico, John Wesley Powell, environmental impacts of the operation of Glen Canyon Dam, recreational aspects, water transfers, the Colorado squawfish, and wildlife. One of the students prepared a map of the basin which was featured in the center of the display and on a handout given to the children attending the festival. The backside of the handout featured the "Colorado River Facts Game" which consisted of a water fact taken from each of the display boards. Fourth and fifth grade students that stopped by the display were given prizes for answering questions on the game correctly. Three of the scholarship students assisted the CCHE coordinator in administering the game during the festival. Thus, this project enabled the undergraduates to learn about the Colorado River system while also experiencing aspects of water education.

The first year of the scholarship program proved to be highly successful. A number of the recipients expressed an enthusiastic interest in water resources which developed as a result of their participation in the scholarship program. Of the three seniors that graduated spring semester, one accepted a job related to water quality in Mississippi, and another decided to enter graduate studies in water resources planning and management at Colorado State University. In addition, four of the scholarship students assisted the Colorado Water Resources Research Institute in some capacity during spring semester and thereby received increased exposure to water resources.

FUTURE PLANS

Due to the success of the first year of the *Program of Excellence*, it is planned to continue many of the programs, including the undergraduate scholarships, summer scholars program, graduate research assistantship, and faculty support. Equipment purchases will be augmented by university commitments for computer improvements from the Dean of Engineering and the Vice President for Research.

The minority institutions collaboration program should be enhanced by this conference and will hopefully result in the establishment of a consortium of HBCUs and MIs in water and environmental resources. A possible method of furthering the collaboration between CSU and the HBCUs and MIs could be through the summer scholars program by funding outstanding undergraduate students from these institutions to spend a summer at CSU doing research with faculty. Such a program would encourage the students to continue into graduate school and expose them to other educational institutions such as CSU. It is also hoped to expand the program to incorporate the Hispanic and Native-American network with a cross-cultural conference on water issues that is planned for 1993.

The implementation of the undergraduate seminar program on water and environmental resources will be accomplished during the coming year. The recruitment of women into water and environmental resources will continue to be coordinated with ongoing programs in the College of Engineering, and involvement with student organizations such as the Society of Women Engineers (SWE) will also be investigated.

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SESSION VI-B

OUTREACH PROGRAMS IN WATER AND ENVIRONMENT

WET AND THE WATERCOURSE:
New Programs in Water Education for the Future

(A Summary of Comments)

by
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PROGRAM OVERVIEW

Water education is taking new shape, new meaning. It has to. In the traditional sense, water education has had its roots in a formal classroom setting with studies in hydrology and water resources management. Now we are seeing the need for tremendous innovation in order to reach a greater diversity of interests -- the public at large.

The challenge now is to get useful, reliable, and genuinely fascinating information to kids who want to know how water reaches their faucets, to teachers who will inspire students with the wonder of the water cycle or with the realities of pollution and drought, to landowners who need to know how to manage a wetland on their property, to citizens who want to understand the intricacies of water rights and adjudication processes -- information for young and old alike -- the list goes on and on.

One program seizing this challenge is the Western Watercourse. This regional and national water education program, centered on the Montana State University campus in Bozeman, began operations in 1989 with a seed grant from the Bureau of Reclamation. Its two branches, National Project WET and the Watercourse (Adult Education and Special Projects) tackle two critical sets of water education needs:

National Project WET supplies an innovative, easy-to-use activity guide and teaching aids to teachers of grades K-12. With this curriculum, children gain the knowledge, skill, and commitment needed to learn about water in the environment and make informed decisions about water management. The Watercourse is a western states adult water education curriculum which will provide mini-workshops and easy-to-use manuals on basic topics of concern -- water rights, wetlands protection and management, groundwater education, and so on.

NATIONAL PROJECT WET

National Project WET (Water Education for Teachers) is a unique youth education program which had its early beginnings in the State of North Dakota. WET is a series of classroom activities and teaching aids helping children learn about surface water, groundwater, and contemporary water resources issues (conservation, pollution, water rights, water allocation, etc.). Through intensive workshops, teachers learn how to use the WET materials and companion teaching aids in their classrooms.

During the last year, the Watercourse received endorsement from the Western Regional Environmental Education Council (WREEC) to fashion Project WET after its other successful national programs, Project Learning Tree and Project WILD. Over the next three years, with the assistance of a distinguished board of directors and a series of WET curriculum writing conferences which will utilize the expertise of excellent primary and secondary education science teachers, a revised WET activity guide and its companion teaching aids will be networked to schools throughout the United States. Teaching aids will include the "Liquid Treasure" water history project, the Groundwater Flow Model Education Project, the Children's Water Story series, a Project WET Electronic Interactive Reference Guide, and much more.

THE WATERCOURSE ADULT AWARENESS PROGRAM

To complement National Project WET, the Watercourse Adult Awareness Program is producing water education materials for adult workshops and meetings throughout the western United States. On the basis of a water education needs assessment currently being conducted by the Watercourse, special water education programs will be shaped by the Watercourse and cooperating agencies and organizations. The survey was distributed to hundreds of water resource professionals, water user groups, educators, and interest groups in the seventeen western states. Each respondent was asked first to identify water education materials and programs already available to the public, this in an important effort to avoid duplication. Second, they were asked to identify the critical water resource topics that need to be tackled in a strong education program -- information that is currently unavailable to the public in an easy-to-use format.

Already we are seeing a distinct need for basic information on water rights and adjudication, how they work, and their effects on how water is managed. We are also recognizing the demand for basic information on wetlands, their functions and habitat, and current law affecting their use and protection. This needs to be presented in a simple, but comprehensive format. A preliminary review of survey responses also points to the need for greater understanding of certain water quality issues and multi-use river basin management. The lack of good water education programs addressing special tribal reservation water resource issues has also been highlighted. In cooperation with other organizations or independently, the Watercourse will build education packages to meet the needs of an information-hungry public.

PROGRAM PHILOSOPHY

To date, the Western Watercourse has tested its programs successfully in pilot states like Montana, Idaho, and Arizona. In the near future, the Project WET curriculum will achieve a national scope. The adult Watercourse programs, however, will tend to address regional information gaps. Regardless of scope, the efforts of the Western Watercourse are designed above all to build leadership, encouraging local participation in water management. In this decade of change, water users will be asked to make important decisions about critical water management problems. To this end, National Project WET will provide youth with the excellent scientific building blocks needed to understand the nature of water and its importance to all users (ranchers, recreationists, municipalities, habitat, and industry). Taking this a step further, the Watercourse adult education program provides the critical link to more informed public participation and the conscious management of the nation's rivers, lakes, and groundwater resources.

EXTENDING KNOWLEDGE ON AGRICULTURAL WATER QUALITY ISSUES: THE ROLE OF COLORADO STATE UNIVERSITY COOPERATIVE EXTENSION

Lloyd R. Walker[1]

The quality of surface and ground water in the United States and Colorado is a subject of increasing concern. It's a very emotional issue because such water is everyone's drinking water. Over the past 20 years, the focus of attention has been point sources of water pollution. These sources have largely been identified, controlled, eliminated or regulated so that they pose a reduced threat to water quality. Currently the public focus has shifted to nonpoint sources of pollution. The size, scope, geographical diversity and production techniques of Colorado agriculture have caused it to be scrutinized for its contribution to nonpoint source pollution. The Colorado Nonpoint Source Assessment Report prepared for the EPA noted that 62 percent of the stream miles in Colorado are impacted by agriculture due to sediment, salinity and nutrients. The focus is primarily crop production since concentrated animal feeding operations are already monitored and regulated. The exception is range cattle feeding in riparian areas or stream beds where their activity may damage fish habitat and cause pollution from sediment due to stream bank erosion. In crop production, sediment pollution due to soil erosion, leaching and concentration of salts from irrigation and leaching and runoff of agricultural chemicals are the primary issues.

The extent of water pollution from crop production is incompletely defined. Sediment from soil erosion due to water and wind is prevalent and well documented throughout the state. Salts are naturally occurring in Colorado soils. Agricultural irrigation has been shown to leach and concentrate salts in rivers and tributaries. The Colorado River has high salt concentrations as it leaves the state. Lower South Platte and lower Arkansas river water gets reused numerous times for irrigation

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which concentrates salts in the water. Agricultural producers in these basins are concerned about reductions in crop yields and are considering growing more salt tolerant crops. Agricultural chemicals have been detected in ground water in Colorado although a complete study of the state is just getting underway. Pesticides have been found in trace amounts, generally at concentrations less than health advisory levels. Nitrate is more frequently found at concentrations above drinking water standards. Studies in the San Luis Valley and lower South Platte river basin have documented this occurrence. However, in an urbanized river basin such as the lower South Platte, the source of agricultural chemical pollution is hard to pinpoint. Such chemicals are also used in urban settings to maintain parks, golf courses and home landscapes. There are two issues with agricultural chemical use: (1) the potential for nonpoint source pollution from applying chemicals on field and landscapes and (2) the potential for point source pollution at sites where applicators mix, load and store chemicals.

Developing solutions to water quality problems from agricultural operations involves the concept of Best Management Practices (BMP's). The guiding concept of BMP's is that proper nutrient, pest, residue and irrigation management will minimize water pollution from agricultural operations. The goal is to eliminate improper use of equipment, inputs and practices.

In addressing soil erosion, the method of dryland wheat production in the state could be considered a BMP. Maintaining a stubble cover on fallow ground reduces soil erosion from wind or water. Continuing studies by Colorado State University researchers are looking at other dryland BMP's such as growing other crops in a fallow rotation. In both dryland and irrigated agriculture, the concept of conservation tillage, reduced tillage or no-till, refer to a BMP which keeps residue on the field to reduce wind or water erosion and the accompanying runoff which introduces sediment and agricultural chemicals into streams.

Reducing salinity problems involves employing BMP's addressing irrigation management. One method of reducing salt leaching to rivers is increasing irrigation application efficiency so that water only in amounts necessary for crop production is applied. BMP's include use of techniques such as irrigation scheduling and new technology such as surge valves. Implementation of these BMP's also will reduce agricultural chemical pollution. Colorado State Cooperative Extension is currently demonstrating such BMP's through their cooperation with other agencies in the Colorado River Salinity Control Project and the Patterson Hollow Hydrologic Unit Area Project (located in the lower Arkansas basin).

Minimizing the potential for water pollution from agricultural chemicals involves BMP's addressing nutrient, pest and irrigation management. Application of plant nutrients timed to coincide with plant needs through split fertilizer applications can be accomplished through chemigation or surge valves. Integrated pest management is a BMP which uses (1) pest scouting to provide information for informed decision making in addressing crop pests, and (2) an array of management techniques including cultural, biological, physical or chemical controls. Irrigation management must work with nutrient and pest BMP's to assure that agricultural chemicals applied are not introduced to surface or ground water. Cooperative Extension is demonstrating these agricultural chemical BMP's in multi-agency projects including the San Luis Valley Water Quality Demonstration Project and the Colorado Agricultural Chemicals and Groundwater Protection (Senate Bill 126) program.

Concern over point source pollution from sites where agricultural chemicals are mixed, loaded or stored was formalized in Senate Bill 126. This law requires safeguards at any site where more than 55,000 pounds of finished agricultural chemical product is handled annually. Regulations are currently being drafted with technical assistance from Cooperative Extension engineering specialists. The concept of the regulations is to provide an impervious surface to intercept spills and leaks and the ability to contain the entire contents of a failed tank.

The BMP's mentioned above are meant to be illustrative of practices which can reduce water quality problems from agricultural operations. However, BMP's must be tailored to a particular crop, and location by combining the knowledge of Colorado State University researchers with the practical experience of agricultural producers. Cooperative Extension is approaching the projects mentioned earlier by drawing on research and practical knowledge to develop a workable set of BMP's for a project area. Demonstrations of these BMP's are then conducted on cooperators' fields and the knowledge shared with other producers.

Most of the water quality programs mentioned above are just beginning; therefore, few results are available. However, based on preliminary work, several observations can be made.

* Many of the BMP's are economically as well as environmentally sound. Progressive farmers are already employing these practices to improve management, cut costs or reduce labor. This broader spectrum of benefits should make adoption of BMP's more attractive.

* Water quality BMP's and existing federal farm policy sometimes have conflicting goals. For example, crop rotation is a BMP that may compromise individual farm payments based on acreage allotments. Reconciliation of these policy contradictions must be done to send an unambiguous message to producers.

* Improved irrigation application efficiency which reduces chemical leaching and runoff may adversely impact the operation of an irrigation water delivery system. Surface irrigation in the lower Arkansas and South Platte reuses river water many times. The reuse is based on irrigation return flows which are the result of low irrigation field efficiency. A significant restructuring of irrigation system operations is implied by promoting improved irrigation application efficiency.

* Irrigation scheduling for fields may not be compatible with water delivery schedules from irrigation companies managing a system.

* Preliminary monitoring studies suggest that current levels of fertilization commonly accepted as good farming practice may cause leaching of nitrogen. The efficiency of a plant to utilize fertilizer decreases at higher fertilizer rates. However, there is still an economic yield response which encourages the high application rates. Studies of

split applications of fertilizer may suggest a way to minimize this problem. However, it may also be necessary to encourage reduced fertilizer applications in sensitive areas through changes to farm policy.

Colorado is fortunate to have generally good quality water for agriculture, industry and domestic use. Agriculture has been identified as a significant contributor to nonpoint source pollution. Education in BMP's and voluntary adoption by agricultural producers may effectively address the problem. Colorado State University Cooperative Extension is using its statewide network of agents and specialists to extend the knowledge necessary to address the challenge.

A REVIEW OF PRIMARY AND SECONDARY WATER RESOURCE EDUCATION CURRICULA OF ATLANTIC COASTAL STATES

Barry W. Fox

Increasing public awareness and concern over environmental issues can be partly attributed to the formal and non-formal educational programs sponsored by a variety of government agencies and public/private organizations. The development of Project Learning Tree (PLT) in the mid-1970's, Project WILD and Project Aquatic WILD in the mid-1980's, and the proposed Project WET, indicate a trend toward national environmental/water resource curricula that are extremely user friendly and non-technical in presentation. These curricula have effective distribution and implementation systems and are good tools for educators who lack a science background. In spite of their popularity, these curricula are only the tip of the proverbial iceberg of environmental/water resource education curricula.

Water Resource Education programs and associated curricula have greatly expanded their scope and methodologies over the past 20 years. There are many curricula not as well known as PLT/WILD that offer sound instruction and effective teaching methods. A national review team sponsored by USDA/Cooperative Extension has recently completed a "Youth Water Education Needs Assessment". Elaine Andrews, University of Wisconsin-Madison, developed the project to:

1. identify youth water quality learning objectives for the non-formal setting,

2. select and categorize water quality curricula according to stated objectives,

3. categorize relevant curriculum materials, delivery systems, and model programs in an understandable/ accessible format, and

4. identify and communicate priorities for meeting targeted objectives.

The project identified nine key water education topics and five learning goals as the basis for its review strategies. With bibliographical references of almost 2000 curricula, correlating publications to these topics and goals provided the criteria for review selection. Selected materials were separated into four (4) categories: state/regional, national, state extension, and unique materials. Educational materials from 26 states and 14 national programs were included in the review.

1. Extension Specialist 4-H Marine/Aquatic Education. Virginia State University, Petersburg, Virginia

Three review assessments were used in curriculum evaluation: water topics, environmental education goals and curriculum format. Curricula were rated on the percentage of <u>mention</u> of a specific topic and these were noted as <u>minor</u> or <u>major</u> mention. Each topic contained numerous subtopics and a range was established from the least mentioned subtopic to the most mentioned. For example, under the topic of "Science of Water", <u>dynamics of surface water</u> was emphasized in 33% of the curricula while 70% emphasized the <u>water cycle</u>. The same approach was used in identifying trends in environmental education goals. It is interesting to note that curricula were noticeably lacking which addressed cultural impacts, formulating questions, values relating to alternative solutions, and evaluating actions in addressing environmental issues.

The review of curriculum format showed some marked strengths and weakness in gender and socio/economic relevancy, special education needs, and lesson plan format.

Several conclusions from the study emphasize the fact that overall, our environmental education efforts are not being integrated into everyday living. There is a lack of sequential, progressive curricula and a lack of training materials and efforts for many of the available programs. "In general, water curriculum is not an availability problem, but a publicity problem". Educators do not know what is available or how to get training and materials.

The barrage of educational materials is overwhelming. Curricula that are developed with no support and training structure, as good as they may be, will ultimately be shelved with all of the other educational collectibles. The project report presents a number of good short term and long term recommendations, including development of materials that address topics such as water related careers and environmental ethics, and institution of regional/national "train the trainer" programs. The first phase of curriculum evaluation is nearly complete. This project will hopefully lead to additional efforts in developing implementation strategies for regional/national youth water education programs.

The project will produce a bibliography of current Water Education Curricula. Copies may be obtained by contacting Elaine Andrews at the Environmental Resources Center, University of Wisconsin, Madison.

In the short time remaining, I'd like to briefly review some of the better non-formal Water Education materials available. I've broadened the scope of this presentation to include publications from across the country. I've provided a biographical listing in this paper for those of you interested in acquiring copies of specific publications. I trust this will help you in your search for good educational materials, as well as prevent duplication of efforts.

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SESSION VII PLENARY

EDUCATIONAL ISSUES

ARMY ENVIRONMENTAL POLICY INSTITUTE INTERACTION WITH HISTORICALLY BLACK COLLEGES AND UNIVERSITIES AND MINORITY INSTITUTIONS

By Kristan Cockerill-Kafka[1]

Introduction

The Army established its Environmental Policy Institute in 1990, following recommendations from the Army Senior Environmental Leadership Conferences in 1988 and 1989. The Institute's mission is to assist the Army Secretariat in developing proactive policies and strategies to address environmental issues that may have significant future impacts on the Army. AEPI is not involved in funding or conducting any technical research and development projects. It is a policy oriented-organization and conducts policy research. Institute projects are studies designed to provide a framework for the Secretariat to make sound policy decisions on a variety of environmental issues.

One environmental issue that may significantly impact the Army is the availability of qualified professionals it needs to meet its environmental requirements. Trends show that between 1985 and 2000, women and minorities will be responsible for the largest share of new entrants to the workforce.[2] A predominant number of minorities attending college, enroll at Historically Black Colleges and Universities (HBCUs) or at Minority Institutions (MIs) and most of these institutions have no or a limited environmental curriculum.[3] If the Army is going to secure qualified personnel in the environmental area, focusing efforts on these demographic groups and institutions is essential.

The Army believes that if it is to meet future challenges, it

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[2] Johnston, William B. and Arnold H. Packer, Workforce 2000: Work and Workers for the 21st Century, Hudson Institute, 1987.

[3] Center for Environmental Intern Programs, The Minority Opportunities Study, August 1989.

must assist HBCUs and MIs in developing their capabilities in the environmental area and their ability to work effectively with the Army. The Institute charter, therefore, includes a mandate to actively involve HBCUs and MIs in the Army Environmental Program. The Institute is committed to providing opportunities for HBCUs and MIs to become fully involved in the Army Environmental Program. To meet this commitment, the Institute has initiated four types of activities: student support, direct contracts, faculty participation in AEPI studies, and involvement in workshops and conferences.

Student Support

A primary concern is to develop the necessary professional base that the Army of the future will need. This requires providing support to students who are pursuing environmentally related degrees. The Institute is currently sponsoring four students working on a variety of environmental research projects. It is important to note that AEPI is not supporting the *project*, but the student. AEPI sponsorship covers the student's stipend, benefits and supplies for one school year.

Contracts

In 1991, AEPI awarded four Indefinite Delivery Contracts (IDC) to HBCUs and MIs. These competitive contracts provide a mechanism to award up to two million dollars over two years to the recipients. Through these contracts, the Institute has issued three delivery orders for environmentally related policy studies.

The first delivery order project was awarded to conduct a study to determine the generation and disposal rates of solid and hazardous waste on Army installations. This project is scheduled to be complete in October, 1992.

The second project was to conduct a study to identify the Army's environmental staffing needs for the future. The contractor is identifying the current status of environmental staffing, identifying areas where there may be future needs, or surpluses, identifying current sources for training and education in environmental fields and how HBCUs can help the Army meet the needs identified in the study.

The final delivery order was issued to produce a video and informational materials to encourage minority and female students to pursue educations and careers in the environmental field. The tape will focus on students in junior high school and highlight the numerous types of environmental careers available, as well as discussing why environmental issues are important to minority communities.

Faculty Expertise

In addition to full contracted projects, the Institute also requests assistance from HBCU/MI faculty as technical experts for various Institute studies. The Institute maintains a small in-house staff and utilizes expertise from various universities, private industry, and other organizations to ensure technical accuracy in all studies. A professor from an HBCU is scheduled to spend the summer at AEPI studying the policy implications of the Clean Air Act's emissions trading program. Faculty from HBCUs and MIs have contributed to the solid and hazardous waste studies and are working with the Institute on the environmental trends project.

Conferences and Workshops

The Institute also hosts several conferences and workshops each year on a variety of environmental topics. HBCU and MI representatives participated in and contributed to the Solid Waste Policy Options Workshop in April 1991, the Hazardous Materials, Hazardous Waste Policy Workshop in June 1991, and the Scenario Building Workshop in April 1992.

Interaction Benefits

The student support and contract initiatives are essential, direct methods to involve HBCUs and MIs in the Army environmental program and to help AEPI meet its mission and charter responsibilities. Although AEPI has a modest budget and these contracts do not represent any substantial funding for the universities, these mechanisms do have other benefits. They provide necessary experience in dealing with the Army contracting process and are helping to develop quality environmental professionals.

The second two initiatives, utilizing faculty expertise and faculty participation in workshops, are more crucial to providing HBCUs and MIs with opportunities to become fully involved in the Army Environmental Program. Participating in Institute-sponsored studies and workshops enables the HBCUs and MIs to become more knowledgeable about the Army, its needs and its concerns. These activities also provide networking opportunities for HBCU/MIs. Generally, workshop and study participants represent industry, regulatory agencies, public interest groups and all levels of the Army from Headquarters to the installations. These organizations often have the budgets and the need to contract out large research and development projects. The experience the HBCUs and MIs are gaining through the AEPI Indefinite Delivery Contracts will enable them to become key players in the contract competition and contract process for future environmental projects.

Future Plans

Plans for the future include continuing all of the above activities and initiating new projects as necessary and feasible. In the near future, the Institute will conduct a study to outline how to most effectively utilize HBCU/MIs' expertise within the Army Environmental Program. AEPI is working with HBCUs and MIs to develop a projects on environmental equity, and environmental awareness.

The Institute is also pursuing several joint projects with other federal agencies. One project would provide support to HBCUs and MIs to develop and/or expand outreach programs to encourage minority and women students to pursue higher education in the environmental field. Another potential project involves creating formal programs that would allow selected faculty and students from HBCUs and MIs to rotate through AEPI and other federal agencies working on environmental policy issues.

Summary

The Institute is committed to utilizing HBCU/MI expertise whenever possible in Institute projects and activities. AEPI continually tries to identify ways and means to help HBCUs and MIs expand their capabilities and experience in the environmental area. Perhaps most importantly, the Institute is also committed to providing these institutions with opportunities to become familiar with and actively involved in the overall Army Environmental Program. Through the variety of activities described here, the Institute is confident that it is providing a strong base for ensuring that the Army will have the qualified professionals and expertise it will need to meet future environmental challenges.

THE FIVE-STAGE PIPELINE OF TEACHER PROFESSIONALISM AND EMPOWERMENT

by

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Through a program of educational entrepreneurship consisting of 25 major activities and projects, The Philadelphia Renaissance in Science and Mathematics (PRISM) raised $7.3 million in three years to involve over 4,000 teachers of science and mathematics in efforts to improve the effectiveness of science and mathematics instruction and in a large urban school district. Eventually PRISM became a center for national programs, such as Project 2061, Project QUASAR, the Urban Math/Science Collaborative, Wilson Institutes, and the NSF-sponsored Comprehensive Regional Centers for Minority Access. Working nearly four years with K-12 science and mathematics teachers in the School District of Philadelphia, we were able to observe and categorize five stages of professional development and empowerment. This blueprint is now being used to create new university/school/business partnerships in Colorado.

SESSION VIII-A

ENVIRONMENTAL CASE STUDIES

Teaching and Research in Environmental Waste and Water Quality Management (EW/WQ) Programs at Alabama A&M University

By
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ABSTRACT

Alabama A&M University is currently to undertaking, a five-year project in Environmental Waste and Water Quality issues by strengthening its academic programs in environmental sciences. The need for such curricular enhancement is predicated upon the fact that there will be unprecedented job opportunities in the EW/WQ area in the decades to come. Alabama A&M University, with its highly developed programs in chemistry, physics, biology, plant and soil science, and civil engineering, ultimate goal is to develop environmental sciences curricular strengths and therefore become a center for training for all, but particularly for minority students, in environmental sciences with emphasis on waste management and related water quality problems. This will be accomplished under the aegis of an interdisciplinary Center of Environmental Research and Training (CERT).

Concerted recruitment, retention and positive experiential learning opportunities have been devised to overcome the lack of interest in environmental sciences among minorities. Furthermore, emphasis are placed on developing multi-university and/or regional media campaigns, outreach programs with high school science classes, specialized workshops for recruitment of personnel, student tuition and support arrangements, and the development of career information tailored for special populations such as Hispanics, Native Americans and African Americans in the areas of recruitment and retention.

INTRODUCTION

Alabama A&M University (AAMU) is an 1890 Land Grant University located in Huntsville, Alabama, one of the fastest growing science and engineering technology centers in the South, and home of the NASA Marshall Space Flight Center, the U. S. Army Missile Command, the U. S. Army Strategic Defense Command, the U. S. Army Redstone Arsenal, and a number of technical industrial support firms, such as Boeing, Lockheed, Rockwell International, Teledyne Brown, SCI, Nichols Research, and Coleman Research. Alabama A&M University has a student population of 5,215 of which 1,259 are graduate students and 3,956 are undergraduates. More than 70 degree programs are offered at the University in five academic Schools; Agriculture and Home Economics, Arts and Science, Business, Education, and Engineering and Technology. Masters degree programs are available in a majority of these discipline areas, and Ph.D. programs are offered in Physics, Food Science, and Plant and Soil Science. The majority of work conducted in Environmental Waste and Water Quality Management is coordinated through the Department of Plant and Soil Science, Biology, Physics, Civil Engineering, Chemistry, and Community Planning and Urban Studies.

GOALS/OBJECTIVES

The ultimate objective of the CERT program is to increase the number of minorities in EW/WQ related sciences and engineering. Specifically, the objectives are:

1) Recruit and retain minority students in environmental science and water quality programs.
2) Strengthen and enhance curriculum to emphasize environmental science.
3) Provide faculty development activities in environmental waste management and water quality issues.
4) Develop outreach programs in EW/WQ.

In order to accomplished the above objectives a Waste Management Advisory Committee (WaMAC) was established. The responsibilities of the WaMAC are to: a.) Prioritize academic specialization in EW/WQ; b.) Select existing faculty members for professional development in EW/WQ; c.) Review existing curricula, equipment and facilities, and new courses developed in EW/WQ in collaboration with newly-trained faculty members; d.) Develop seminars and workshops in EW/WQ for faculty, staff and student development; and, e.) Conduct formative and summative evaluation each year.

PROGRAM DESCRIPTION

Curriculum and Faculty Development

Alabama A&M University currently offers a B.S. degree in Environmental Science. The Curriculum Development in the EW/WQ Program involves the augmentation of this major by adding courses in some instances and modifying others so as to strengthen the environmental chemistry, health physics, environmental engineering (solid waste management), environmental toxicology and water pollution and management areas. The Departments of Chemistry, Physics, Biology, Civil Engineering, Community Planning and Plant and Soil Science already offer courses that are related to environmental and water quality issues (Table 1). New courses will be developed over a five year enhancement period. Workshops, seminars and experiential learning opportunities are offered to both faculty, in the form of short term study leave, and to students, in the form of summer co-op placement in public and private work places.

Recruitment and retention

The initiation of a Teaching and research EW/WQ at Alabama A&M University necessitates the development of successful recruitment and retention strategies to attract, retain, and educationally improve high-quality minority student scholars and undergraduates. Implementational emphasis, therefore, are continuousely weighted toward recruitment, publicity, promotion and program image-enhancement. Minority student recruitment and retention will be implemented and monitored over a 5-year period.

Table 1. EW/WQ Related Courses

- Air pollution: Theory and Techniques
- Soil and water pollution
- Principles of hazardous materials managements
- Methods of environmental analysis
- Hydrogeology
- Introduction to radioactivity and safety
- Environmental risk assessment
- Environmental regulation and policy
- Instrumental methods
- Toxicology
- Solid waste disposal
- Seminar in environmental sciences
- Limnology
- Microbial ecology
- Radiation biology
- Environmental engineering
- Hydrology
- Public health engineering
- Waste water treatment

Outreach and Student Development

A multifaceted outreach effort are conducted involving, firstly, a 6-week Apprenticeship for juniors and high school students with interest in chemistry, physics, biology, mathematics and agriculture. The program involves coursework, laboratory work, workshops, seminars, field trips, career counseling and a follow-up program. Also efforts are made to liaise with student clubs to organize tutoring for local pre-college students. In addition to this, we plan to take part in a Science Fair for HBCU/MI to increase minority student participation at the local, state, regional and national levels by assigning tutors and mentors as consultants to students and teachers with interest in EW/WQ. Also we plan to develop and sponsor a summer Science Fair for elementary, middle, high school and college level students. An environmental club will be organized in addition to an apprenticeship program in concert with local and regional government and industrial agencies and national laboratories. Special workshops and training seminars will be held for high school, middle school and elementary school teachers from already established In-servive Teacher Training Center at Alabama A&M University.

There is concerted effort to infuse EW/WQ related topics and programs into the on-going outreach programs as shown in Table 2. A pre-college prototype laboratory school curriculum activity such as the Saturday Academy Program has also been initiated (a 2-3 hour weekly section). This project will also be implemented in a five-year period.

Research Program in Waste Management and Water Quality

The environmental and water management program at Alabama A&M University mainly falls under the aegis of the Departments of Biology and Plant and Soil Sciences' ecological and environmental research and teaching thrust. Researches in holistic ecological and environmental aspects date back to 1969. Reseach is currently in progress in the following areas.

- Air Toxics Emission and Transport
- Waste Packaging in Resin
- Analysis and Design of Structures Related to Waste Handling, Disposal, and Treatment Facilities.
- Air Stripping and Transport of Volalite Organic Compounds (VOCs)
- Geotechnical Analysis - Related with Underground Storage Structures and Underground Pipe-Network System.
- Project on Preliminary Assessment (PA) of Formerly Used Defence Sites (FUDS)
- Materials for Infrared Detectors and Electro-Optic Devices.
- Restoration and reclamation of contaminated surface mineland reclamation and their use for constructed wetland
- Use of microalgae for wastewater clean-up and as biofertilizers
- Modelling contaminant leaching in relation to soil tillage and organic matter relative to groundwater pollution
- cropping systems to reduce groundwater pollution by plant nutrients (nitrate)

Summary of Some Current Research Activities

Scientists are currently engaged in intensive study to understand the adsorption/desorption phenomenon and the kinetics of interactions of metals and P with soil and mineral (Al-oxide) surfaces. This is of fundamental importance in understanding water quality because these reactions influence the levels of P and other elements in surface waters, especially following interactions with colloidal particles present in the soil water continuum. Some scientists in the participating Departments are also interested in the determination of the stability and fate of selected pesticides, nutrients and metals in the subsoil and groundwater environments of the Mid-South region. Specifically, researches are directed towards the following problems:

TABLE 2. Pre-College Programs at Alabama A&M University

Program Name	Duration	Grade Level	Description
Research Apprenticeship Program Department of Agriculture/USDA ***(M. Floyd)***	8 weeks	12	An intensive research experience in the laboratory of a research scientist on campus.
Alabama A&M Summer Youth Program (University) ***(Doris Hall)***	2 weeks	6-12	Program is designed for early identification, counseling, pre-college enrichment and academic enhancement.
Minority Biomedical Research Support Summer Program (NIH) ***(P. Kale)***	8 weeks	9-12	Program designed to create an interest in students to pursue careers in the biomedical fields and conduct biomedical research.
Health Careers Opportunity (NIH) Program - Project SHARP Project SHARP II (State, Hughes) ***Contact: J. Jones***	4 weeks 6 weeks	Pre-Freshman Community College Students	The Summer Honors Academic Reinforcement Program, Project SHARP, is designed for academic enrichment in science and mathematics, study skills, test taking skills, problem-solving, reading comprehension, time management, and value clarification.
Science Olympiad (University) ***Contact: Wiley Henderson***	2 days	7-12	Competitive science experimentation, questions, etc.
Scientists of Tomorrow (University) ***Contact: Rather Brown***	1 day	7-12	College visitation and outreach in select science disciplines.
Upward Bound (DOEd) ***Contact: James Gurley***	12 months	9-11	Help low-income first generation college bound students complete high school and get into and out of a post secondary institution of their choice with necessary finances.
Bridge Program (Component of Upward Bound) (DOEd) ***(J. Gurley)***	8 weeks	College Freshmen	Enrichment program for high school graduates.
High School Student Science Training Program (NSF) ***(Jerry Shipman)***	5 weeks	9-12	Enrichment program in science, math, English, test taking, career exploration, and computers.
Middle School Student Science Training Program (NSF) ***(Jerry Shipman)***	2 weeks	6-8	Enrichment program in science, math, English, test-taking, career exploration, and computers.
Elementary School Student Science (NSF) ***(Jerry Shipman)***	2 weeks	4-5	Enrichment program in science, math, English, test-taking, career exploration, and computers.

1) The better understanding of the sorption of particular plant nutrients (i.e., P, NH_4-N, Cu, Zn) by soils and soil mineral components. Of particular interest is elucidation of sorption mechanisms and the role they play in nutrient availability and environmental pollution via nutrient leaching into the groundwater. This is accomplished by performing soil and soil mineral physical chemical studies involving the use of traditional adsorption and kinetic models.

2) Air Toxics Emission and Transport: The objectives of this project are to develop, apply, and maintain a credible, tailorable, and defensible performance assessment capabability consisting of conceptual models, computer codes database (laboratory and in-situ experiments) for determining the effects of large motor firing and/or open burning on the community environment. Emission rate from the source are predicted using the POLU 11 computer code and with an in-situ experiment. Pollutant dispersion models (Inpuff and ISC-s/l) are being used to simulate pollutant concentrations at various receptors.

3) Air Stripping and Transport of Volatile Organic Compounds (VOCs): The objectives are to determine the effects of soils physical and chemical properties on retention factors for two VOCs in the unsaturated layer of subsoils; predict the removal rate and efficiency of VOCs by air stripping technology. The approach includes doing adsorption studies, soil column flow studies, and modeling (the following may be applied a) Fick's Equation, b) Raout's Law, c) Henry's Law, and d) the Continuity Equation.

4) Waste Packaging in Resin: Radioactive waste needs to be compacted to take up the minimum space and then encapsulated to prevent the escape of radioactive components. Silicaceous glass is used as an encapsulant but there are problems with the technology because waste has to be heated to temperatures in excess of 600°C. Gases are evolved and have to be trapped and reprocessed. Thus there is a need to use a lower temperature encapsulant such as an inorganic resin. The requirements are that the resin be impermeable and not chemically active, not be flammable, be able to withstand appropriate high integrated flux dosage of energetic radiation and be practical to process. The objectives of this research are i) to find the optimum silicone glass resin for encapsulation of radioactive waste, ii) to develop a range of test procedures for making appropriate assessments, iii) to understand the deterioration of thermoset silicone resins under radiation, and iv) to develop new progressive gelling spray technology for the encapsulation of nuclear waste. Using a Pelletron accelerator in house, specimen blocks will be subjected to appropriate radiation and changes in integrity and permeability assessed. Mechanical property changes will be determined. The irradiation damage will be modeled and basic studies made on observed property deterioration.

5) Pesticide Transport in Relation to Tillage Practices and Organic Matter: This project deals with reducing the transport of pesticides from the surface to the groundwater. We are testing appropriate management practices for reducing pesticide losses to the aquifer. Best management practices for pesticides are designed such that contact with organic matter in the soil is maximized and preferential flow is minimized. Field research is performed at the Alabama A&M University Research Station and laboratory research is performed with undisturbed soil columns excavated from the field plots. Eight tile lines are installed. Pesticides and tracers (e.g., chloride and bromide) are monitored in the soil columns, tile outflow, wick and suction lysimeters, piezometers and in groundwater observation wells. Also, water and pesticide flow paths under the different management practices will be traced and compared by using dye experiments. Chemical transport through field soils will be simulated with the EPA RUSTIC model and Cornell "Preferential" model. Numerical Simulation of Groundwater Contamination will be performed.

6) A project on the Preliminary Assessment (PA) of Formerly Used Defence Sites (FUDS) is also in progress: The objectives of this project are to identify and describe eligible restoration projects to be accomplised under Defence Environmental Restoration Program (DERP) and/or to determine those sites where no projects are warranted. Data on each designated site will be gathered from interviews, archival research, official documents and a site visit. Each site inspection with 35mm photographs and color slides will be documented. Reports will be prepared on each site or facility according to the format specified by COE. Preliminary Assessment (PA) is the first phase in hazardous waste sites assessments. This usually followed by Environmental Impact Assessment (EIA) and then Environmental Impact Statement (EIS). Remedial actions require that a Remedial Investigation/ Fesibility Studies be performed (RI/FS). The PA-EIA-EIS-RI/FS is driven by RCRA and CERCLA.

ACCOMPLISHMENTS FY 90-91

A) Administration

During the October 24, 1991 meeting of the Alabama A&M University Board of Trustees, Dr. Jones presented the work currently being conducted through the university in the areas of Energy, Environmental Technology and Waste Management, and was instrumental in getting the Board of Trustees to approve the establishment of two new research centers for research and training:

*The Center for Environment Research and Training (CERT)
*The Howard J. Foster Center for The Irradiation of Materials (CIM)
The overall administration of AAMU program involves an Executive Director and two Co-Directors:
Dr. Jeanette JonesExecutive Director
Dr. Sunnie A. Aburime Co-Director (Outreach)
Dr. Robert Taylor Co-Director (Research)

1. A Waste Management Advisory Committee has been established to provide general oversight of the program activities.
2. A Technical Advisory Committee consisting of faculty representatives from the departments involved in the program activities has been established.
3. The Environmental Technology and Waste Management (ET/WM) Consortium directors worked with AAMU staff to establish a university-wide recycling program.

B) Curriculum and Faculty Development

Undergraduate Curriculum Development

-Alabama A&M University currently offers a B. S. degree in Environmental Science, and a number of undergraduate courses have already been identified as being related to toxic and hazardous waste management (see Table 1 below).
-From joint meetings between HBCU/MI project directors and chairpersons of Departments of Chemistry, Physics, Biology, Civil Engineering, Food Science, Community Planning and Plant and Soil Science, it was determined that these courses should be used to provide an Environmental Science minor option to interested students.

Graduate Curriculum Development

A number of courses critical for quality graduate training in Environmental Science presently are offered in Departments of Physics, Biology, Urban Planning and Plant and Soil Science (see Table 2). From these courses, a student in any of the above departments can develop a program with concentration in Environmental Science.

Table 3. Under-Graduate Courses Related to EW/WQ and Training at Alabama A&M Univ.

Course #		Course Title
CE	304	Environmental Engineering
CE	305	Hydrogeology
CE	408	Soil Mechanics and Foundation
CE	409	Public Health Engineering
CE	410	Transportation Engineering
CE	455	Wastewater Treatment
BIO	450	Radiation Biology
SPS	461	Applications of Soil Physics
SPS	470	Soil, Plant, and Water Analysis
SPS	472	Soil and Water Pollution
SPS	473	Air Pollution: Theory and Techniques
SPS	476	Remote Sensing of Earth Surface Features
PHY	453	Introduction of Nuclear Physics

Table 4. Graduate Courses Related to Environmental Science at Alabama A&M Univ.

Course #		Course Title
PHY	502	Biophysics
BIO	510	Radiation Biology
BIO	511	Biological Control
BIO	562	Community Ecology
BIO	563	Population Ecology
BIO	564	Limnology
BIO	565	Phycology
BIO	552	Insect-Pest Management
BIO	560	Environmental Biology
BIO	561	Physiological Ecology
BIO	660	Ecosystem Dynamics
BIO	661	Advanced Population Ecology
SPS	505	Instrumental Techniques (New)
SPS	530	Principles of Experimentation
SPS	610	Crop Ecology
SPS	625	Stress Physiology of Crops
SPS	650	Advanced Soil Chemistry
SPS	651	Advanced Soil Physics
SPS	674	Principles of GIS
UPR	542	Planning and the Environment
UPR	545	Environmental Policy Planning
UPR	566	Environment of Human Issues in Planning

Participation in EW/WQ related Faculty and Student Development Activities

- Alabama A&M faculty members Drs. M. Campbell, R. Brown, S. A. Aburime and R. Taylor attended the curriculum development workshop at Jackson State University, Jackson, MS, June 4-7, 1991. Some suggestions from this meeting have already been incorporated in the Environmental Science option of some departments.

* Dr. S. A. Aburime, Assistant Professor of Soil and Water Engineering, participated in the MSIP proposal development. The proposal was funded and it will enhance the development of a computerized course in Environmental Science using Integrated Computerized Instruction Support Systems (ICISS). This should further support the teaching and training of students in Environmental Waste Management and Water Quality. The developed modules will be distributed to other HBCU/MI and interested institutions. Courses are currently been developed in Water Quality, Solid Waste Management, and Agricultural Runoff Effects.

- Dr. S. A. Aburime was certified through an intensive summer course (1991) in Hazardous Waste Management at University of California, Davis.

- Drs. M. Campbell, R. Brown, R. Hassan, J. Jones, S. Aburime and R. Taylor took three students to the conference on Health Effects of Toxic Substances and Contingency Planning, Sept. 26-27, 1991, Atlanta, GA.

- Dr. R. Taylor, attended a two-day symposium on the application of agricultural analysis in environmental studies held in Atlantic City, NJ (Summer, 1991).

Interactions with Scientists from National Agencies and/or Labs.

* Four Alabama A&M scientists were invited to present a 2 day workshop to EPA scientists (Washington, DC, November 5-7, 1991) on Environmental Science topics. Dr. M. Campbell presented on environmental toxicology; Dr. S. A. Aburime presented on groundwater monitoring and assessment; Dr. G. Jenkins presented on radioactive waste packaging and Dr. R. Taylor presented on bioremediation.

- Dr. R. Taylor, Associate Professor of Soil and Environmental Chemistry, met with scientists from LLNL (along with scientists from Southern University, Prairie View A&M University and Jackson State University) to develop cooperative research projects (March, 1991). Alabama A&M is developing a proposal on the use of algae to remove heavy metals from wastewater.

- Drs. G. Sharma and R. Taylor visited with Battelle PNL scientists at the Washington office (September, 1991) to explore possible research subcontracts and cooperative projects. Scientists from Alabama A&M University responded to a Request for Proposal (RFP) from Battelle with a number of proposals EnvironmentalWaste Management and Water Quality areas.

- Alabama A&M University maintains cooperative agreements with S.R.E.L. through Dr. R. Taylor participation in projects with Dr. D. Adriano. Together they have collaborated on four manuscripts on residual studies pertaining to heavy metals and phosphate in soils amended with municipal sewage sludges.

- Five faculty and four students are currently working with the U. S. Army Corps of Engineers to provide preliminary site assessment data for five sites.

Infusion of EW/WQ Topics in Courses
Faculty in the departments of Biology, Chemistry, Physics, Civil Engineering, and Plant and Soil Science currently are reviewing and upgrading their science curricula to infuse Environmental Science topics into existing courses.

C) **Recruitment and Retention**

- Alabama A&M's enrollment is at an all time high of 5,215, the Admission Office has been provided information regarding environmental areas and center and is currently developing a new brochure to highlight these areas.

- Alabama A&M University has developed a cooperative agreement with Oakwood College in Huntsville, Alabama, to enhance recruitment and retention of minorities in underrepresented science, mathematics and engineering disciplines.

- Three undergraduate students interested in studying Environmental Science attended the conference on Health Effects of Toxic Substances and Contingency Planning, arranged by Clark Atlanta University, in Atlanta, GA September 26-27, 1991.

- One graduate student was provided the opportunity to spend the summer at University of California at Berkley through DOE-EMCOM program and Associated Western Universities.

- Another graduate student spent the summer (1991) at Battelle PNL in Richland, WA, where he performed research on the effects of soil properties on air stripping of volatile organic compounds. This work laid the foundation for his Ph.D. proposal.

D) **Outreach and Student Development**

-The Alabama A&M University EW/WQ program has integrated with on-going pre-college programs on campus. These programs are summarized in Table 2. During the summer of 1991, Environmental Science seminars were presented to groups of pre-college students from Chicago. More than the students our funding can accommodate has already been identified for the summer of 1992.

-A 6-week apprenticeship program for junior and senior high school students with interests in chemistry, physics,biology, mathematics and agriculture was established within the Mathematics and Science MRCE program. The apprenticeship involves coursework, and laboratory work, workshops, seminars, field trips, and career counseling in Environmental Remediation and Hazardous Waste Management and computer literacy.

-A University recycling program has been fully implemented in conjunction with the City of Huntsville recycling program, all 75 buildings are scheduled for full implementation under this program.

-Additional EW/WQ related topics and programs currently are being infused into the on-going outreach programs shown in Table 2.

E) **Research and Training**

Our use of the HBCU/MI funds to coordinate and sharply focus on environmentally related research and training opportunities has led directly/indirectly to the following:

Alabama A&M University involvement in:

DOE and EPA/EPSCOR statewide projects in research and Trainig involving the University of Alabama, University of Alabama in Birmingham, University of Alabama in Huntsville, University of South Alabama, Auburn University.

Oakridge National Laboratory representative visited the campus on December 12th to discuss and identify areas of collaborative research interest. This was a follow-up of an October meeting which the Dean of Agriculture and Home Economics and the Chair of Plant and Soil Science met with Oakridge National Laboratory representative in Oakridge, TN.

Conclusion: In all, it can be said that Alabama A&M University has a rather young but vibrant teaching and research program in environmental waste and water quality management. This and similar programs will be of great importance to the future of the nation relative to the training of minority personnel to fill this critical area of need. Our experience so far seems to suggest that finding students to participate in the EW/WQ program is not as difficult as finding the resources to teach and train them.

TOXIC COMMUNICATIONS & ASSISTNCE PROJECT
ALBANY STATE COLLEGE
ALBANY, GEORGIA

Ellis E. Sykes and David C. Robinson

MISSION

Albany State College's (ASC), Toxic Communications & Assistance Project's (T-CAP) primary mission is to provide low-income, and rural minority communities with assistance in their efforts to understand and then act upon environmental hazards that threaten their drinking water. This assistance includes both technical training and communication networking through workshops, seminars, roundtable discussions and the Southern Action Newsletter. Additionally, T-CAP aims to foster partnerships with resource people from other Historically Black Colleges and Universities (HBCU) and communities that are seriously harmed by existing uncontrolled hazardous waste sites.

BACKGROUND

In low-income and minority communities, there are many desperate problems: housing, hunger, drugs, teen pregnancy, jobs, crime and the overall impact of racial discrimination. Most of these issues seem to be far more life threatening and immediate than toxic pollution concerns. Therefore, it is no wonder that "environmental issues", at least in the classic sense, do not make the cut among the TOP TEN issues in the Black community. However, pollution is just as much a part of the landscape, and just as much a manifestation of oppression as poverty, drugs, crime and neighborhood deterioration. Environmental injustice is not an issue to many low-income and minority groups because of what they perceive to be more important concerns. However, it represents a real issue.

Many threats to drinking water, health and the environment comes from dangerous environmental practices. Landfills, storage treatment facilities, surface impoundments, deep injection wells and incineration are types of disposal practices which have long been

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condemned as the worst way to manage our wastes. These types of facilities have often been placed in low-income and minority communities because this represents the path of least resistance. Further the injustice is compounded by patterns of racial and ethnic bias, as is documented by the U.S. General Accounting Office and the Commission for Racial Justice of the United Church of Christ. Furthermore, the Center for Environmental Intern Program Fund (CEIP) has published a Minority Opportunity Study. This study assesses the state of minorities in the environmental field. The study found that: 1. Most employers in the environmental field are seeking qualified minority candidates but many employers are unsuccessful in finding candidates, 2. Members of minority groups are not exposed to environmental issues and career opportunities. 3. No educational or career opportunities exist to encourage minorities to enter the environmental fields, and 4. The current supply of minority environmental professionals and recent college graduates in the science and engineering field is very limited.

T-CAP

The Toxic Communications & Assistance Project is unique in that three major organizations are involved to provide communities with assistance surrounding water quality issues. The Citizen Clearinghouse for Hazardous Waste (CCHW) is a national grassroots environmental crisis center that helps organize community groups. The Legal Environmental Assistance Foundation (LEAF) is a public interest law firm that provides legal assistance to communities facing toxic hazards. Then, of course, there is Albany State College which has been involved in many projects addressing the needs of minority communities and has a very capable science staff in place to provide technical assistance.

T-CAP is geared to address water quality issues, as well as serving an educational role within the minority community on environmental issues and opportunities. Currently, the project focuses energy, resources and attention on the most seriously harmed communities. By combining the efforts of Albany State College, the Legal Environmental Assistance Foundation (LEAF), Citizens Clearinghouses For Hazardous Waste (CCHW) and HBCUs throughout the region, residents of low-income, rural and minority communities in Georgia, Alabama, and Florida are provided with the important assistance they need to achieve environmental justice and safe drinking water.

T-CAP also has a student intern program which is aimed at fostering partnerships between students with technical backgrounds and communities suffering from contaminated waste sites. We offer this assistance on a year round basis through an on going program that provides technical information and conducts preliminary site assessments. ASC has developed eleven (11) courses in Environmental Resources designed to teach students through research and community service. We have the environmental professionals in place as well as the facilities and labs. A summer enrichment program for minority and disadvantaged high schools students and pre-freshman college students, is being sponsored with the support of the Ford Foundation. This institute will involve 8 weeks (4 weeks in classroom work and 4 weeks of lab and field investigations) of intensive environmental issues. During the academic year students also participate in efforts of this kind through workshops that are planned for undergraduate students interested in environmental science and health careers.

T-CAP currently provides network and community outreach services in Alabama, Georgia and Florida through the publication of the Southern Action newsletter. The project acts as a clearinghouse by linking communities up with other environmental organizations depending on their needs. T-CAP provides technical assistance and follow-up consultation on understanding the complex topics surrounding environmental issues. Site assessments and community surveys are provided to the most seriously harmed communities with the assistance of student interns.

T-CAP also has in place a placement program that encourages graduate and undergraduate students to work with other environmental organizations during the summer months. Additionally, our graduate environmental class also are encouraged to take part in research activities that will positively impact on environmental problems in our communities.

WHAT THIS PROJECT MEANS TO THE COMMUNITY

Most Southern Communities facing environmental hazards lack the money and the connections to get the technical help they need to understand and act on these problems. The lack of money and connections is most severe in Black communities. Black low-income communities are often the last to know that a problem exists and the last to know the nature of the threat the problem poses. T-CAP goes beyond simply filling in missing technical resources. Black communities in the South have few reasons to trust the word of outside experts. This history of mistrust can be overcome through good faith, patience and persistence. However, this takes time. Unfortunately, time lost in dealing with environmental hazards can cost lives. T-CAP seeks to mobilize resource people at HBCUs whose presence in minority communities will, we expect, reduce the time it takes for the community to decide whether or not that resource person can be trusted. This will result in a stronger relationship developing between the college and the surrounding communities and hopefully help enrollment at these institutions.

By recruiting and motivating students to go into environmental sciences and health careers areas, we anticipate that this will help to relieve the shortage of minorities in these areas.

One positive consequence of T-CAP's activities is to foster more biracial coalition efforts. Both white and black communities are hungry for technical resources. Work on waste issues in the south has consistently shown the ability of these issues to transcend historic racial and class divisions.

The following preliminary study was conducted by graduate students in ecology during the summer of 1990. The study will be completed after additional visits to the area have been made.

A PRELIMINARY STUDY OF THE HUMAN POPULATION ADJACENT TO THE HERCULES 009 LANDFILL SITE.

The Hercules 009 landfill covers 16.5 acres several miles north of the business district of Brunswick, Georgia. The landfill is in a marshland about 1 mile east of costal wetlands associated with the Atlantic Ocean. Hercules, Inc. has used 7 acres of the landfill site for disposal of toxaphene, a pesticide from the Brunswick Plant. The company has reported disposing of 19,300 tons of waste at the site. From 1975 to 1980, the site operated under state permit, which was revoked in July 1980 because of hazardous constituents found in the water of wells in the area.

The landfill is situated atop several feet of peat and marsh deposits over a shallow sand aquifer. The nearest residential area is about 200 feet from the site. Municipal and industrial wells in the area usually tap the deeper Limestone Artisan Aquifer; however, residential wells generally tap the shallow aquifer.

The purpose of this study was to survey the people in the area to determine if the Hercules Landfill has had a negative impact on the people of the community. the specific objectives were:

1. To ascertain the racial composition of the population inhabiting the community adjacent to the Hercules Landfill site.

2. To determine if members of the community have experienced health problems either real or imagined as a result of having lived in the landfill area.

3. To ascertain if any families of the community receive well water from the immediate area surrounding the landfill site.

4. To determine if the families of the community have experienced unusual orders from the landfill.

Procedures:

After identifying the study site, the researchers handed out questionnaire to residents adjacent to the landfill. Each person contacted was given sufficient time to respond to the items of the instrument. When this task was completed, the questionnaires were collected and analyzed.

Results:

The inhabitants occupying the community surrounding the Hercules Landfill site were poor people living at or just above poverty level of existence. Living in this community were both black and white families; the majority of the families were white. Some of the families had members who once worked or still employed at the Hercules plant. The survey instrument revealed that about one half of the families who live in this community have experienced health problems that they believe are caused by chemicals associated with the Hercules Landfill site. The health problems cited were: (1) heart diseases (2) stomach problems (3) urinary problems (4) cancer (5) periodic dizziness (6) vomiting (7) headaches and (7) general weakness.

Most of the families, it was discovered, receive their drinking water from the wells that tap the groundwater near the landfill. Many of these families reported having periodically noticed an unusual odor coming from their drinking water. Further, on rainy days, they have noticed that their well water is more cloudy than on non-rainy days. Many of these same families said that they have experienced unusual odors in the air, but they could not ascertain where the odors originated.

Summary:

Poor white families constituted the greatest percentage of families in the community near the Hercules Landfill. However, a few black families are exposed to the chemicals of the landfill. Approximately one half of the families living in the community have experienced health problems that they believe are caused by chemicals associated with the landfill. Further, most of the people in the area receive drinking water from wells that tap the shallow aquifer which is believed to be contaminated by toxaphene.

ENVIRONMENTAL DEGRADATON OF GREATER DHAKA CITY

M. Habibur Rahman *

ABSTRACT

The geometric growth of population and rapid industrialization of Greater Dhaka city (GDC) have resulted in massive exploitation of natural resources and pollution. This study focuses on the environmental degradation of GDC due to pollution created by domestic and industrial wastes. These wastes are not handled by organized ways. This paper prsents the characteristics of solid wastes and leachate from solid wastes produces in GDC. Organic food wastes with hign moisture content are the major constituent of solid wastes. But the disposal of these organic wastes is being done in an uncontrolled and unsanitary manner. Only 15% of total population of the city are being served by sewerage authority . Rest of the population either have their own sanitation facilities or nothing at all. The surface drains, aiming to carry storm water, also carry human excreta from slum areas and leachate from solid wastes and there by causing serious environmental problems. The different industries of GDC dispose their untreated hazardous wastes into the river system. Therefore, waste disposal methods creat water and air pollution problem. The waste disposal method in GDC can be improved by raising public awarness with the adoption of appropiate pollution control standards and legislation.

INTRODUCTION

Dhaka, the Capital City of Bangladesh is expanding vary rapidly. During monsoon period of the year 1987 and 1988, this country suffered two serious floods. At that time Dhaka experienced an unprecedented degree of flood level, 1·5 m higher than normal level for a period of about four weeks. In this situation the Government of Bangladesh decided to construct flood protection structures to surround the GDC areas. The first phase of this work has already been completed. The construction of these structures will enhance the rapid growth of the city. This will resulted massive exploitaton of natural resource due to rapid growth of new residential, commercial and industrial areas. Present waste management trend indicate that the disposal of wastes from these areas are indiscriminate. Therefore, the disposal of domestic and industrial wastes would cause asthetic, land use, water pollution and air pollution problem and would pose a serious threat to environment and health. Hence, waste management system of GDC require special attention to reduce environmental degradation.

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DOMESTIC WASTES

Domestic Sewage

The present status of sanitary practic in Dhaka city is shown in figure 1. From Figure 1, it is apparent that about 30% of the city population is surved by unsanitary system consisting of kutcha latrin and open defecation directly into living environment.

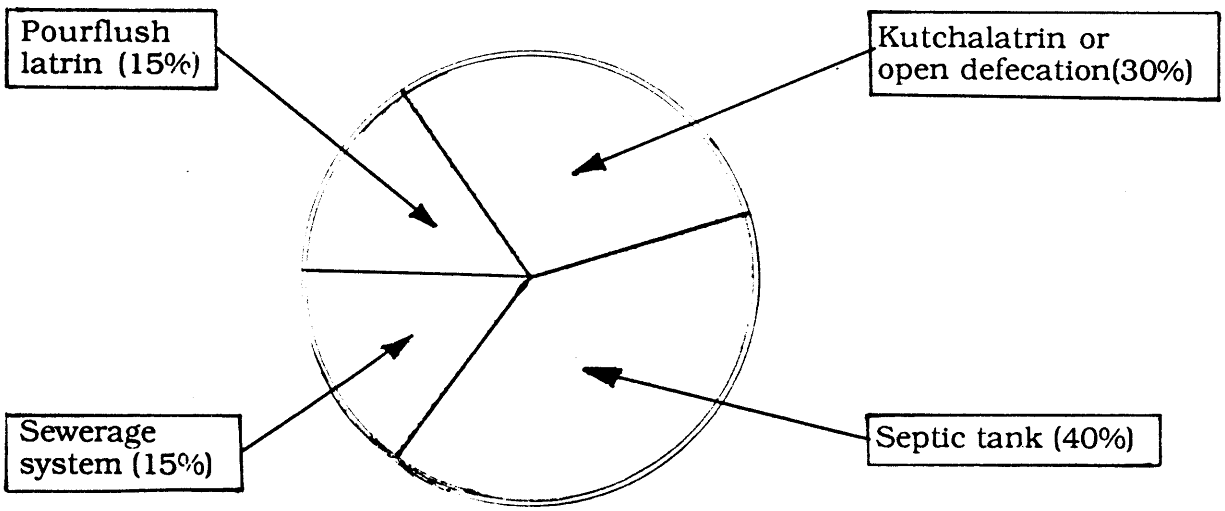

Figure 1 Sanitation Coverage of Dhaka City in 1990.

Solid Wastes

Solid wastes collection in Dhaka city is about 1000 - 1500 ton/day which is about 50% of total generated wastes. Table 1 shows the physical characteristics of solid wastes. For physcal characteristics samples were collected from the bins of residential and commercial areas (Rahman, 1991) . Table 2 represents the characteristics of leachate of solid wastes collested from bottom of the bins. However, these characteristics always change as different reuseable items are reclaimed at various disposal stages.

Wastes from Slum Area s

About 40% of total population (7 million) of GDC are slum dwellers. A large amount of untreated wastes are produced in slum areas. These wastes find their ways through open drains into open water bodies. Typical characteristics of water pupming into river system from different lagoons and waste water from slum areas are presented in Table3.

INDUSTRIAL WASTES

About 554 different types of industries are situated within GDC. Among these 160 tannery industries are concentrated in a particular area (Hazaribagh) on the bank of the river Buriganga and 166 textie industries with some other industries are concentrated in the central part of GDC (known as Tejgaon industrial area) and the rest of the industries are scattered in different areas of GDC.These are small to medium scale interprises. Therefore, a huge amount of water is required for different industrial uses. Only a small portion of that water is incorporated in their products and lost by

Table 1 Typical Components of Solid Wastes

Constituents	% by dry weights	
	residential area	commercial area
Food wastes	84.37	79.49
Paper	5.68	7.22
Plastics	1.74	1.48
Cloths	1.83	1.59
Glass, ceramic, metal, grass, other construction materials	6.38	10.22
Note : moisture content = 80 - 95%		

Table 2 Characteristics of Leachate

Component	Range	Typical Value
pH	4.5 - 6.0	4.75
Suspended solids,mg/l	3000 -14000	10000
Chloride,mg/l	1300 - 5000	1400
Nitrate, mg/l	0 - 200	50
Phosphate,mg/l	0 - 15	5
COD, mg/l	5000 - 17000	14000
BOD_5,mg/l	5000 - 15000	9000

Table 3 Typical Water and Waste Water Quality

Collection Sources	pH	BOD_5, mg/l	Suspended Solids(ss), mg/l
Water pumping into river system from selected lagoons	6.7 - 7.1	40 - 150	150 - 300
Drainage system of slum areas	6.4 - 7.1	400 - 1700	500 - 2500
Surface wash from slum areas	6.4 - 6.7	800 - 1200	800 - 3000

evaporation. the rest find their ways into open water courses as wastewater. Typical effuent qualities of selected industries are presented in Table 4.

Table 4 Typical Effluent Quality of Selected Industries

Industries	p^H	BOD_5, mg/l	Suspended Solids, mg/l	Toxic substance,mg/l
Tanneries	8.6 - 10.4	660 - 2800	1300 - 11500	chromium = (0.5-10.5) Amonia = (100 -35)
Textile or Dying	6.8 - 11.8	180 - 1000	100 -5000	chromium = 9.6

GENERAL DISCUSSION

The indiscriminate disposal of pollutents into the environment creats extremely serious health hazard to the population of GDC, particularly for the poor people living in slum areas who use open water sources for their household and other purposes. Table 3 indicate that both waste water from drainage system of slum areas and water quality from open water bodies are extremely polluted. They receive surface wash from slum areas with very high pollution potential (BOD_5 = 800 - 1200 mg/l and ss = 800 - 3000 mg/l) . The present status of GDC sanitation practice as presented in Figure 1 clearly indicate that 30% of the city population have unsanitary system consisting of kutcha latrin or open defecation directly into the living environment. Where sanitary facilities are not available in GDC, the septic tank effluent and sludge , bucket latrin wastes and decomposed residential, commercial and industrial wastes are being discharged into storm drains or open water bodies without being aware of effluent quality and their detrimental effects on the living environment. The human excreta collected from service latrin is also discharged into the manholes of the sewerage system. The existing sewerage sytem (15%) of GDC is currently operating at its maximum capacity. The sewage treatment plant in GDC is not adequate for the treatment of sewage to a satisfactory level. As a result, the effluent from the treatment plant with high organic load is discharged into the river system. Hence environmental degradation mainly due to water pollution is the major causes of diseases of the slum settlements. According to the Report of the Task force (1991) , at any time 30% to 40% of the slum dwellers suffer from water or air born diseases. Therefore, the present state of sanitation practice and waste management system require special attention to improve the situation . The present sanitaton practice can be improved by providing comprehensive sanitation policies with the adoption of a clearly defined pollution control legislation. Since 40% population have septic tank system, that can be modified by connecting the septic tank into small bore sewerage sytem. This system will be less expensive compared to conventional sewerage system. About 40% population of GDC areas are slum dwellers. In most cases they donot have proper sanitation practice. Therefore, awarness regarding environmental sanitation have to creat among them by providing low cost latrin so that they will use latrin instead of open defecation into living environment. Total generated solid waste in Dhaka city is about 2000 - 3000 ton/day. Characteristics of solid wastes presented in Tables 1 indicate that the major components of solids wastes is organic food wastes with high moisture content. The disposal of solid wastes are conducted in GDC in uncontrolled and unsanitary manner. Exposed dumping of organic wastes in an open areas atracts birds and vermin and cause asthetic and air pollution problem . There is overflow of leachate of high organic loads (BOD_5 = 5000 - 15000 mg/l and ss = 3000 - 14000 mg/l) during rainy season which ultimately causes surface and ground water pollution. Therefore, the development of strategy for solid waste management is urgently needed to reduce water and air pollution. A large number of industries are within GDC. Some of them are major polluting industries. The effluents with high pollution potential as presented in Table 4 are discharged into river system. These waste are inorganic,organic and toxic in nature. In any developed country, the polluting effluent with these characteristics are not allowed to discharge into natural water sources. To prevent this a clearly defined effluent quality standard is required.

RECOMENDATION

On a critical examination of existing waste management system of GDC, the following recommendations are made to improve the situation.

(1) Awarness have to creat among general public of GDC regarding environmental sanitation and health education.

(2) Low cost sanitation facilities have to provide to the slum dwellers for the improvement of their sanitation practice. Small bored sewerage system can be employed for the disposal of septic tank effluent.

(3) The improvement of existing sewage treatment plant is urgently needed.

(4) Development of strategy for proper solid waste management is required to control surface and ground water pollution.

(5) A well defined effluent quality standard and legislation is immediately needed to control indiscriminate disposal of industrial wastes into open water sources and into the living environment.

(6) To improve overall waste management system in GDC, it is essential that the different agencies involved in city development and in monitoring and controlling the GDC environment should recognize the nature of the problem for the development of pollution control legislation and standards.

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WATER QUALITY REMEDIATION OF ACID MINE DRAINAGE USING WETLANDS: A CASE STUDY IN CARBONDALE, OHIO

by

Subramania I. Sritharan[1] and Victor I. Okereke[2]

Abstract: Water draining from many coal mines are known to be highly acidic with high concentrations of iron. The study describes the use of man-made wetlands to reduce acidity and concentrations of iron in acid mine drainage (AMD) from coal mine areas which bear pyrites in their strata. Previous research on wetland mechanisms have provided wetland designers with valuable information on soil, water and plant behavior in wetland systems. Biotic and abiotic mechanisms influencing the oxidation processes and the abstraction of iron have been studied in detail. Hydrologic parameters such as flow rates, water depth and patterns of subsurface flow play a major role in the efficacy of man-made wetlands. The details of field studies at the Carbondale wetland in Athens County, Ohio are presented indicating the impact of hydrological parameters on the iron removal efficiency of the system. Results are useful in designing wetlands to achieve higher levels of iron removal.

INTRODUCTION

The use of wetlands to remediate acid mine drainage (AMD) has been tried in a number of coal mining areas in the U.S. including Ohio. It is relatively inexpensive to construct and maintain a wetland. This is well adapted to many places and can enhance the ecosystem by providing natural habitat for a number of plant and animal species. The Carbondale wetland in Athens County, Ohio was constructed on the basis of these ideas by the Ohio Department of Natural Resources (ODNR) as part of its to efforts to reclaim abandoned mine lands. The AMD comes out of a mine (Mine T 14) that was abandoned in mid 1920's. Thecoal from this drift mine was Kittaning 6 which is known for its relatively higher pyritic content. The

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discharge is approximately 11.0 l/s of AMD with an average pH of 3.0. The average concentrations of iron and acids (mostly sulfuric acid) in the AMD are about 110 mg/L and 1000 mg/L respectively . Before the construction of the wetlands, this iron and acid ladden water flow drectly into Hewitt Fork, which is a small tributary of Hocking River. Overall, the impact of similar AMD on the stream water quality in Ohio as assessed in 1980 with regard pH, iron and sulfate contents is significant.

The Carbondale wetland system receives AMD flows from two points on the slope surface which might have been the adits during periods of active mining operation. The major flow is to the east and the minor one is closer to Carbondale. The AMD from the major flow is channeled through six large cells in series and the minor flow through three smaller cells, also in seres. The two flows merge before entering the polishing pond, which is the final cell in this wetland system. Water from the polishing pond discharges into Hewitt Fork. The cells were planted with cattails (*typha latifolia*) which has been claimed to reduce iron and acidity (Mitsch et al., 1985). Two different kinds of substrates - mushroom compost and commercial manure were placed in different cells over 9" layers of lime. The 12" thick layers of the substrates were intended to provide nutrients for the cattails (Figure 1). Monitoring activities began with a set of preliminary measurements in February, 1991. Major portions of sampling and measurements have just been completed. Chemical analysis and synthesis of observations are currently in progress. The frequency of measurements was scheduled to be monthly.

FORMATION OF ACID MINE DRAINAGE

As an area is mined, the void that is created is filled by air. If the area is not reclaimed, oxygen-bearing water from the surface will seep into the mine. In the presence of water and oxygen, pyrites in the coal is oxidized to iron (II) sulfate and sulfuric acid as in Equation (1) below. The reaction is mediated by bacteria such as *thiobacillus ferrooxidan*.

$$2FeS_2 + 2H_2O + 7O_2 \text{ -----> } 2FeSO_4 + 2H_2SO_4 \qquad (1)$$

The rate of the above reaction is very slow, but the retention time in most mines is generally long enough for the reaction to proceed to an appreciable extent before the water discharges to the ground surface. The above reaction is responsible for the high concentration of iron and acid in the water draining from the said abandoned coal mines.

In the presence of oxygen and excess acid, the iron (II) sulfate can be oxidized to iron (III) sulfate as shown in Equation (2) below. As in the first reaction, this reaction can also mediated by bacteria.

$$4FeSO_4 + 2H_2SO_4 + O_2 \text{ -----> } 2Fe_2(SO_4)_3 + 2H_2O \quad (2)$$

A good part of the reaction takes place in the wetland, but evidence from this investigation suggests that some of it takes place before the flow reaches the surface. In the wetland, the iron (III) sulfate reacts with water to precipitate iron (III) hydroxide, as shown below.

$$Fe_2(SO_4)_3 + 6H_2O \text{ -----> } 2Fe(OH)_3 + 3H_2SO_4 \quad (3)$$

In a system with sufficient detention time, such as the wetland cells described above, the iron (III) hydroxide settles to the bottom as a reddish-brown precipitate.

MONITORING PROGRAM

Determination of the performance of the Carbondale system in improving the quality of AMD and the correlation of its performance with important hydrological, water quality, substrate chemistry and biological parameters were the main aims of the study. The hydrological parameters included flow rate, rainfall, water levels and hydraulic conductivity of the base stratum. Water quality parameters included concentrations of major cations and anions, temperature, BOD, dissolved oxygen, pH and conductivity. For soil (substrate) the following are being observed: pH, cation exchange capacity, temperature, major cations and anions. Plant studies included the determination of plant density, uptake of metals and other parameters related to the growth of cattails. Microbiological studies included the determination of type and count of colonies of bacteria in the AMD and substrates. The number of sampling points for water quality parameters was initially twelve but was recently increased to sixteen. These points were chosen to permit the monitoring of each cell as well as the different substrates.

IMPACT OF THE WETLAND ON IRON AND ACIDITY LEVELS

The major concerns about AMD are its high concentrations of iron and acid. The levels of iron and pH measured in the system are given in Figures 2 and 3. The acidity (sulfates) were seen to remain high throughout the system. It appears that cattails do not contribute towards acidity reduction in this system as was originally postulated. There was no appreciable decrease in acidity as the water passes through the system. The deposition of iron (III) hydroxide in the wetland system is being achieved as expected from Equation (3). Figure 4 gives the reduction in iron concentration reduction along the system.

The mushroom compost seemed to be a better substrate that the Fermway organics because the cattails grew better in those cells where the later was used as substrate. Besides, the iron removal was also better. However, there is no conclusive evidence to demonstrate the above assertion. The researchers plan to do more research into that aspect of the wetland dynamics in the months ahead. Further, the average concentration of total iron (110.0 mg/L) in the inflow to Carbondale system is slightly higher than the critical level of 100.0 mg/L for cattail survival suggested by Samuel et al. (1988). U.S. Bureau of Mines (Hedin and Nairn, 1991) has suggested sizing criteria for wetlands. For AMD with pH of 3.0-3.5 the wetland size required must be $1m^2$ per 5 grams of iron removed per day. Carbondale wetland is removing about 12 grams of iron per square meter per day. The iron removal efficiency is of the order of 60%. It is imperative that ways and means should be found to reduce acidity in the system. Efforts are underway to secure additional funding to enable the researchers to investigate the use of limestone and/or other products to reduce the acidity in the final effluent from this wetland system.

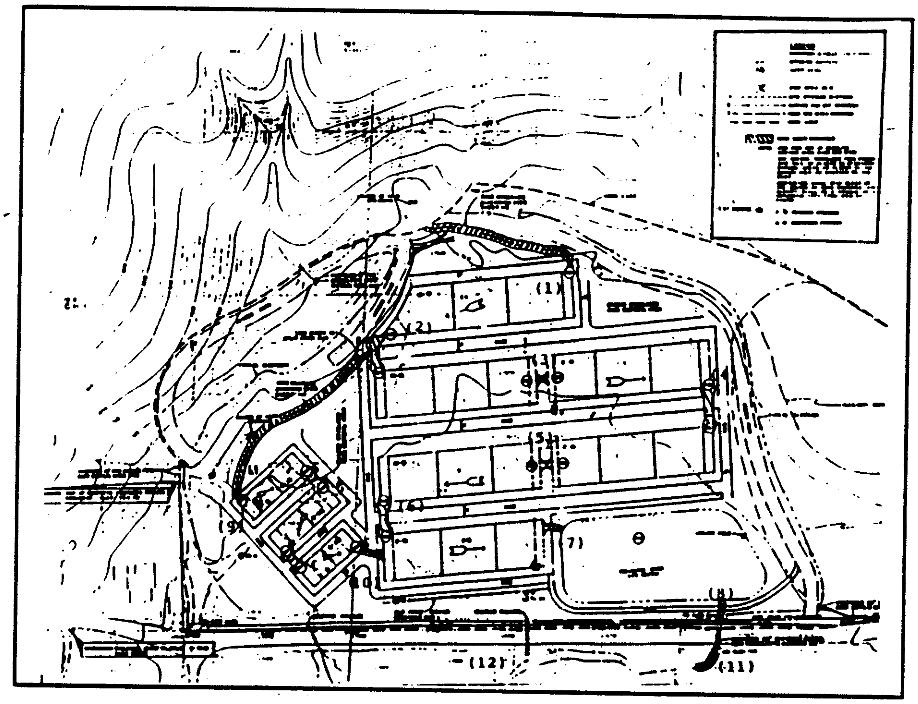

Figure 1 - Carbondale Wetland System

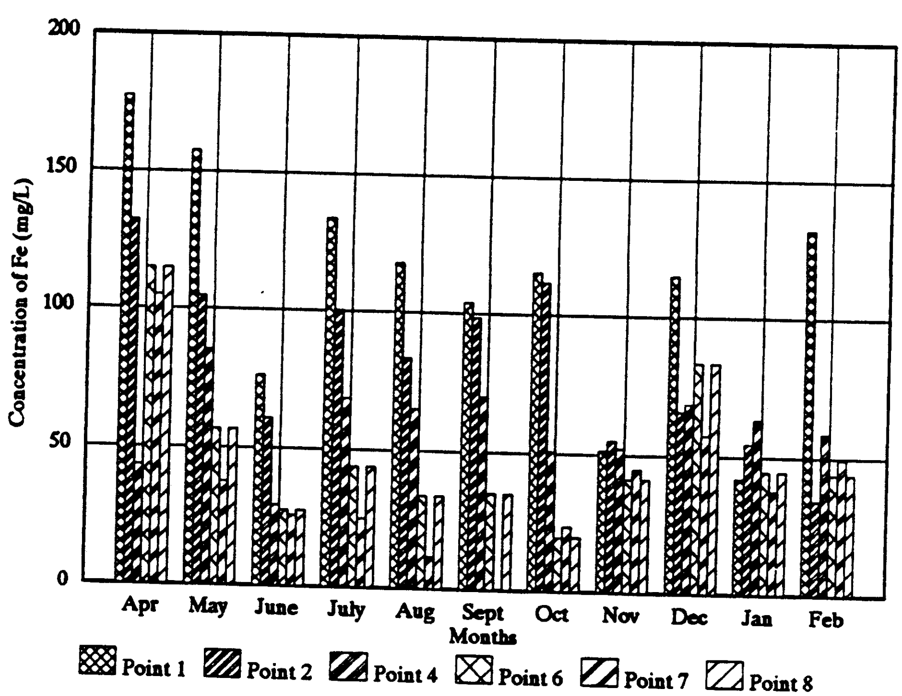

Figure 2 - Iron Concentrations at Different Points in Carbondale

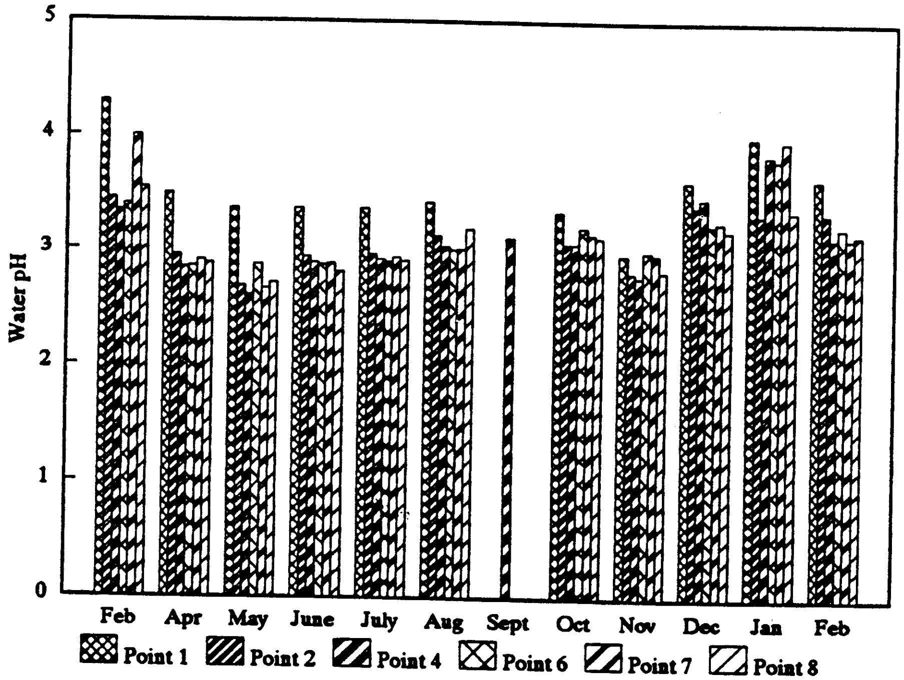

Figure 3 - Variation of pH in the Carbondale System

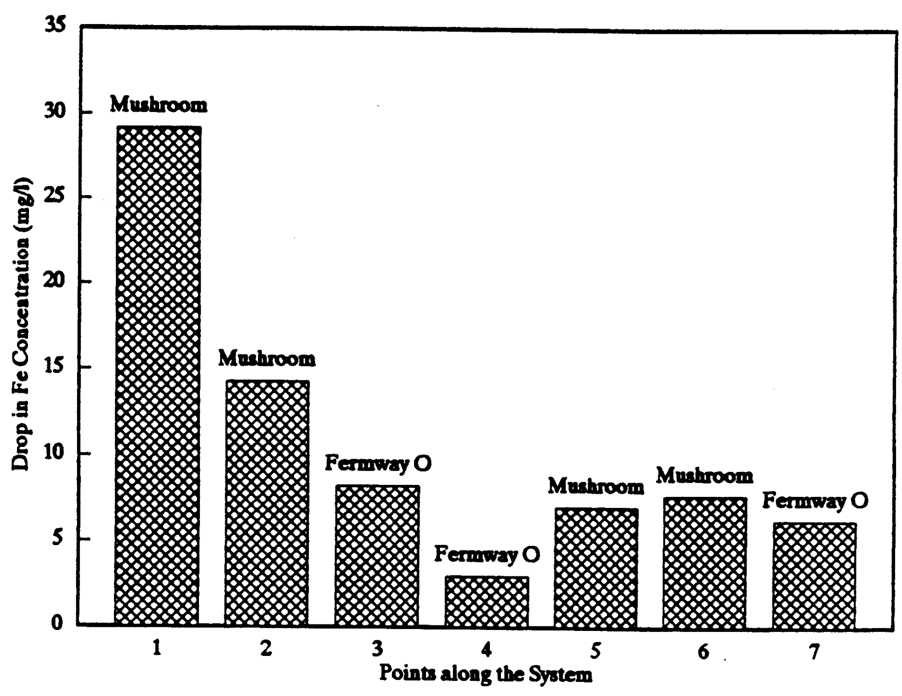

Figure 4 Reduction in Iron Concentrations

CONCLUSION

Finally, the use of man-made wetlands to improve the water quality of drainage from abandoned coal mines appears to be very promising. The technology is simple, inexpensive and nearly maintenance-free, once all the bugs are eliminated and the ponds are sized correctly. What is described here is the early stages of an attempt to study how such a system would work and to determine the important, chemical, biological and hydrologic parameters that facilitate the natural remedial action of wetlands. The ultimate goal of this effort is to generate knowledge that could lead to the design of better wetlands for better water quality remediation.

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SESSION VIII-B

INTERNATIONAL WATER RESOURCES EDUCATION

Adaptive Research and Training Needs for Sustainable Water Use in Agriculture

Arumugam Kandiah[1]

1. INTRODUCTION

Although, by virtue of the hydrological cycle freshwater is renewable, for all practical purposes, it is considered a finite resource. The World Commission on Environment and Development (WCED, 1987) reported that the global water use, which doubled between 1940 and 1980, would redouble by the year 2000. It further noted that some 80 countries, with 40 percent of the world population, already suffer from water shortages. The crisis of water quantity is further aggravated by deterioration of water quality caused by inappropriate developmental activities and improper water management practices.

On other side of the equation, the rapid population growth calls for increased economic activities. Increases in food production will have to be actively pursued and this will inevitably press more heavily on the water resources which are already under strain. Much of the pressure will be in the developing countries, where over three-quarters of the world's population live and it is in these countries that 90 percent of the future population growth will occur. Unless basic food needs of these people are met, the goal of sustainable development will remain a dream.

2. NEED FOR NEW WATER TECHNOLOGIES

Until the middle of the 1970's much of the increases in food production in developing countries was attributable to horizontal expansion of arable land, in which irrigation development played a central role. Having reached the limits of good arable lands and water resources, there has been a "slow-down" to the lateral expansion process since then, and the emphasis has shifted to increasing production per unit land area. For example, the rate of global irrigation

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development was around 2.3 percent per annum in the mid-1970's, but it started to decline soon after and the current estimated rate is less than 1 percent per annum (FAO, 1990).

There is greater need now than ever before for new technologies that would: produce more per unit of land; increase water use efficiency (greater dry matter yield per unit of water consumed); permit reuse of water including drainage flows and other sources of wastewater; and enable farmers to conserve rainfall and soil moisture under rainfed farming conditions. Although a number of such technologies do exist in the developed countries, experience shows that they cannot be directly applied in many developing countries. While the basic principles of the technologies remain valid, these technologies need to be adapted to the physical and socio-economic conditions that prevail in developing countries. Concurrently, people need to be trained, namely: researchers to verify and adopt technologies; extension workers to transfer technologies to farmers; and finally farmers to apply them in the field. These bring home the vital role of capacity building for sustainable agricultural development.

3. NATIONAL CAPACITY FOR SUSTAINABLE AGRICULTURE

The ability of a country to manage its natural resources and to follow sustainable development paths is determined to a large extent by the capacity of its people and its institutions. The Preparatory Committee for the United Nations Conference on Environment and Development (UNCED, 1992) emphasized the importance of national capacity building for sustainable development and defined national capacity to encompass the country's human, scientific, technological, organizational, institutional and resource capabilities. Research, education and training thus constitute important elements of national capacity.

The Food and Agriculture Organization of the United Nations (FAO) accords high priority to national capacity building, including strengthening research, education, extension and training programmes. FAO's Medium Term Plan of 1992-97 (FAO, 1991) states the following objectives with regard to research and technology development and education, training and extension:

- to strengthen research capabilities in developing countries, giving particular attention to policies and planning of agricultural research, the organization and management of research systems and programmes and evaluation, adaptation and adoption of traditional and emerging technologies for sustainable agricultural development; and

- to strengthen agricultural education, training and extension at national level through upgrading the capacities of agricultural schools, colleges, faculties and universities; promoting appropriate in-service training and career development programmes; and promoting participatory and low-cost extension methods.

Building this national capacity will require the efforts of countries themselves in partnership with developed nations and the international community. The commitment of governments to develop sound and coherent national policies on research, education and training and the implementation of such policies is vital for environmentally safe and sustainable development.

The FAO's International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD, FAO. 1991) is designed to assist developing member nations in policy formulation, planning, developing and managing water resources on an integrated basis to meet the present and future needs for agricultural production, taking into account environmental considerations. The IAP-WASAD, while identifying five priority subject areas for action, recognizes the key importance of adaptive research, institutional strengthening, human resources development and technology transfer to achieve its objective. The issues and specific activities identified for international technical cooperation in the following sections are based on the strategies and recommendations of the FAO's International Action Programme.

4. NATIONAL WATER MANAGEMENT RESEARCH PROGRAMMES

Water related research programmes in most developing countries are rather limited in scope and often discontinuous and fragmented. Furthermore, research tends to be limited to technical issues, with very little attention given to social, institutional, environmental and economic aspects of water management in agriculture. A study by the International Irrigation Management Institute (IIMI, 1989) concludes that much of the research in developing countries is a single discipline kind, following conventional disciplinary lines, studying one or a few aspects in relative isolation. In countries with large irrigation systems, there have been a number of research projects and specialized research institutions, supported by national governments as well as by external technical assistance and funding agencies. Some notable ones are: the Mona Project in Pakistan, the Water Technology Centre in India, the National Irrigation Adminstration in the Philippines and the Water Research Centre in Egypt. While these institutions are recognized for their contribution to water management research, their performance is far from optimum.

Many factors contribute to the current problems of adaptive research in developing nations. Some important ones are: the absence of national water research policy, the lack of coordination between various water research institutions; and inadequate budget, human resources and institutional capacity.

5. NATIONAL EDUCATION AND TRAINING PROGRAMMES

Shortage of educated, trained and experienced human resources at all levels is a major constraint to agricultural development in general and water management in particular in many developing countries. Lack of qualified and trained human resources has profound effect on the performance of research institutions and the quality of their output. Although manpower deficiencies are frequently considered in terms of numbers, shortcomings can occur in terms of quality and appropriateness of training and institutions that train and employ manpower. Thus in order to address human resources development comprehensively, it is important that all three of these issues, namely, quantity, quality and institutional factors are considered in an integrated manner.

Manpower shortage is particularly acute in many Sub-Sahara African countries. On the other hand in Asia, Near East and Latin America professionally trained manpower appears to be adequate. In Asia for instance, the lack of career opportunities, salary structure and job satisfaction have resulted in "brain-drain" leading to temporary setbacks. In most countries, there is serious shortage in management skills.

Many countries lack education and training policies with regard to water management. The result is that there is serious imbalance between demand and supply, in terms of discipline as well as level of training. For example, there could be a glut of university degree holders in liberal arts and biological sciences and dearth of university and diploma trained persons in engineering and applied technologies and vice versa.

Often, in-service training particularly of extension workers is inadequate as well as education and training of farmers.

6. SOME AREAS FOR INTERNATIONAL ACTION

Four country missions carried out under the FAO's IAP-WASAD to evaluate status of agricultural water use and identify areas for technical cooperation (IAP-WASAD, 1991a, b, c, d) reveal the following:

- there was need in all four countries to strengthen adaptive research, particularly on water management to improve water use efficiency at the farm level;

- lack of coordination between agricultural and the various water institutions was found to be a major problem in three of them;

- one country, was seriously constrained by lack of trained manpower at all levels; and

- in all cases training was lacking at intermediate levels, namely, technicians and extension workers.

Based on the findings of the IAP-WASAD regional assessment studies and country missions and the results of FAO technical assistance projects in more than one hundred countries worldwide, the following priority areas are identified for international technical assistance in adaptive research and training in water management.

6.1 Research and Human Resources Development Policies

Many developing countries do not have clearly defined national water resources management policies, and in the few which have them, research and training are not given adequate importance. Hence there is need to assist developing countries to establish research and human resources development policies in the context of sustainable agricultural development and water resources management.

6.1 Coordination, Monitoring and Evaluation

Lack of coordination and fragmentation of water management research is a serious constraint. In the ministries of agriculture water management research is mostly limited to irrigation agronomy, within the framework of irrigated crop production. The research focus of irrigation departments is on hydrology, hydraulic structures and operation and maintenance of physical systems. Research in the university departments of agriculture and engineering tends to be academic and isolated. These institutions compete among themselves for limited human and financial resources.

There is need to provide assistance to national governments to establish mechanisms for coordinating national research programmes in water management and monitor and evaluate progress. In this context, the creation of an autonomous authority, such as a national water authority or commission could be the solution.

The commission, suitably placed in the government's administrative structure could serve as an effective instrument to promote integrated water management research as well as training and human resources development.

6.3 Manpower Planning

Lack of information on the availability of trained manpower, trained manpower needs, and institutional requirements to produce the necessary manpower is often a major limitation to comprehensive and sustainable human resources development in most developing countries. There is need to assist countries on manpower development planning. Several methodologies are available and FAO (1987) has developed a methodology to plan manpower development for irrigation and has tested it in some selected countries. There is need to develop alternative models, test them and actively pursue the goal of national human resources development.

6.4 Support to Universities

In many developing countries, universities are passive in adaptive research and specialized training such as short courses and in-service training programmes. The curricula tend to be theoretical with limited practical training; consequently, the graduates produced are not groomed enough to meet real world problems. In this regard, the transfer of experiences of some universities of developed countries, particularly those which possess international research and training expertise, could be useful. An FAO technical assistance programme with the Indian Council for Agricultural Research (FAO/UNDP, 1985) is designed to promote post-graduate education and adaptive research in agriculture through a "twinning arrangement" between Indian institutions and a number of universities from USA and UK and Australia. There is need for similar programmes to strengthen the linkages of universities with national research institutions and promote mutually supporting programmes.

7. CONCLUSIONS

Management of water resources to meet the food needs of a fast expanding population on a sustainable basis, in face of water scarcity and water quality and environmental degradation, is an immense task. It calls for, among other things, new technologies that are oriented towards improving water use efficiencies and strengthening national capacities for adaptive research and training. Discontinuity and fragmentation of water management research and inadequacy of trained manpower in terms of quantity and quality are major constraints to water management in many developing countries. International assistance is needed but such assistance should be geared towards strengthening national capacities, so that the countries can undertake their own adaptive research and training programmes. International assistance for developing national research and human resources development policies; establishing mechanisms for coordination, monitoring and evaluation of research; manpower development planning; and assisting universities to update curricula and collaborate more closely with research institutions deserves priority. The focus should be on assisting countries to strengthen national capacity building which is "helping countries to help themselves".

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TOWARDS SUSTAINABILITY IN WATER SECTOR IN DEVELOPING COUNTRIES -- CHALLENGES FOR ENGINEERING EDUCATION

Pekka E. Pietilä[1], Tapio S. Katko[1] and Osmo T. Seppälä[1]

During the 1980s a lot of effort was put forward worldwide to achieve "water for all by 1990" but in spite of several encouraging experiences the failures had to be admitted. At the end of the decade there were regions where more people were without proper water and sanitation facilities than in the beginning of the decade. For the failure to achieve sustainable water supply two reasons were often given: a) unsuitable technology from industrialised countries was brought to developing countries and b) the people (users) were not properly involved. Commonly the engineers were blamed. During recent years these two problems have been carefully addressed but still many water systems are inoperational.

SUSTAINABILITY

The main problem has been the lack of sustainability. The basic requirements for sustainability are: a) institutional capability to deliver water services and b) sound financial management to enable the running of activities. The UNDP symposium on strategy for water resources capacity building held in June 1991 distinguished three basic elements of capacity building (UNDP 1991):

- creating an enabling environment with appropriate policy and legal framework
- institutional development, including community participation
- human resources development and strengthening of managerial systems.

It has commonly been the government policy to subsidize water services. Massive support by external agencies has partly enabled this policy until now. However, it has become evident that without consumer payments it is impossible to provide reliable water services. Some recent studies have indicated that actually the consumers are already paying for their water services much more than previously believed - but informally. (Katko 1991)

In many developing countries implementation of new water systems has been popular while properly organized operation and maintenance and cost recovery have been neglected. It has unfortunately been too attractive to measure the achievements in water supply and sanitation only by the number of people covered by new schemes. This criteria was commonly accepted by both the regional water engineers and the external support agencies. However, at the same time existing systems were deteriorating and became inoperational because maintenance did not get enough attention. Thus on the one hand new systems were covering more people but on the other hand older systems were not any more able to serve the population they used to.

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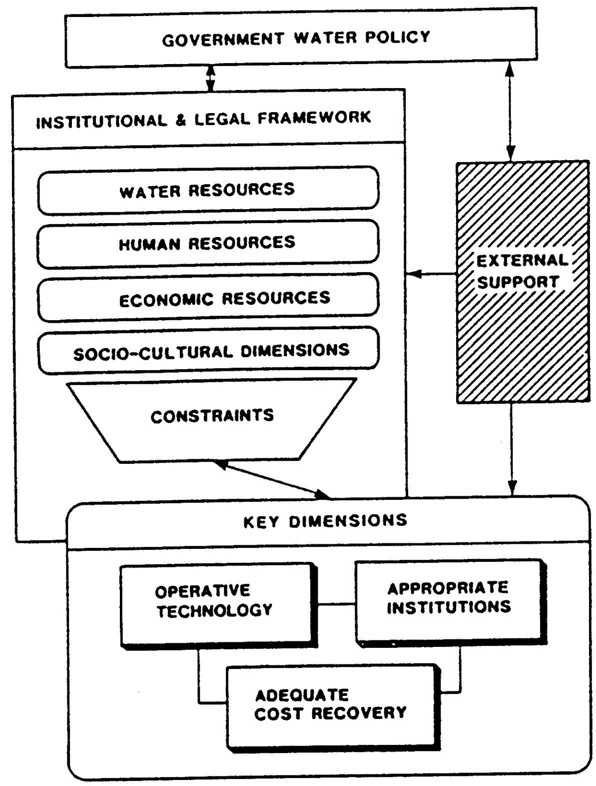

Figure 1. The key dimensions of sustainable water supply (Katko 1991)

In the developing countries the professional requirements for engineers, who have a key role in water sector, are in many respects more demanding than for their colleagues in industrialized countries. In addition to traditional technical activities they must have an active role in the capacity building in the sector, which calls for the ability to cope with tasks related to policy issues and institutional, managerial and human resources development.

An extremely important element in institutional building is staff motivation. Even if the people at different levels in the organization have received proper education and training one cannot expect good results if the working environment is not challenging. Attractive salary is an important factor. In some developing countries, however, salaries in public sector have unfortunately fallen below the subsistence level. But payment is not the only key factor to a work motivation. Another as important factor is the mental satisfaction one gains through performing his duties. In general this can be achieved with appropriate combination of challenges, responsibilities and freedom in the particular task.

The work motivation is clearly linked with the organizational set up. Until now in many countries common centralized water sector administration did not give much space for true decision-making or innovation at any level. Even the price of water countrywide was decided centrally without taking into account the variations of needs in different parts of the country.

DEVELOPMENTS IN ENGINEERING EDUCATION

The engineering education in developing countries is often based on the practice established in and for the industrialized countries. However, the role of an engineer in a developing country, where the institutions and policies are not yet properly established, is quite different from his counterpart's role in a developed country, where the practice in water supply has mainly been created by earlier generations.

If engineers from developing countries have pursued their studies in industrialized countries, according to standard curricula, they have mainly learned technologies and principles applicable to industrialized world. However, there have been some tailor-made training programs, which properly address the special requirements and circumstances in the developing countries, still not neglecting the benefits that studying in a country with functioning infrastructure can offer. Since the 1970s more than 100 East African B.Sc. level engineers have done their M.Sc. studies on the 18-months´ Postgraduate Course in Water Supply and Sanitation at Tampere University of Technology (TUT) in Finland.

The program of this course has been developing along as the ideas and strategies of water and sanitation sector development have changed. In the early years the emphasis was more on technology and rural problems, but recently the urban challenge, environmental issues, management and capacity building have gained increased attention. Good management is essential for proper provision, operation and maintenance of water and sanitation facilities. Besides technical management, e.g. financial management, leadership and human resources development have formed an increasingly important part of the program. Although engineers are not expected to take over all the activities and functions in the sector organizations from professional managers, economists, training specialists etc., they definitely benefit a lot more from such a wide program compared with a narrow technical or theoretical program. (Sandelin and Seppälä 1992)

Almost from the beginning the Postgraduate Course at TUT has had a strong emphasis on an ambitious but at the same time practical M.Sc. thesis project done in the participants´ home country. Thesis projects have proved to be difficult to implement and supervise, but on the other hand they have been extremely challenging for both the students and the course organizers. Since the problems in developing countries have become more complex, also thesis topics tend to become more demanding and multidisciplinary. Sometimes thesis topics have been forced to be changed or modified after initial planning, because the topics have been too sensitive for decision makers, especially if policy issues or cost sharing have been dealt with.

CHALLENGES IN THE FUTURE

Rapid urbanization in developing countries will bring a great challenge for water engineers in the future. In the past both governments and external support agencies concentrated their development efforts to rural areas in order to improve people's living conditions. The aim was to make rural areas so attractive that people would not move to cities and thus the problems caused by the growth of urban population could be avoided. However, in spite of all these efforts many urban centres have grown a lot faster than planned. Consequently the problems in water supply and sanitation in many cities have developed much more severely than was estimated some years ago. Population growth and urbanization have in many areas caused major environmental problems and deterioration of water resources.

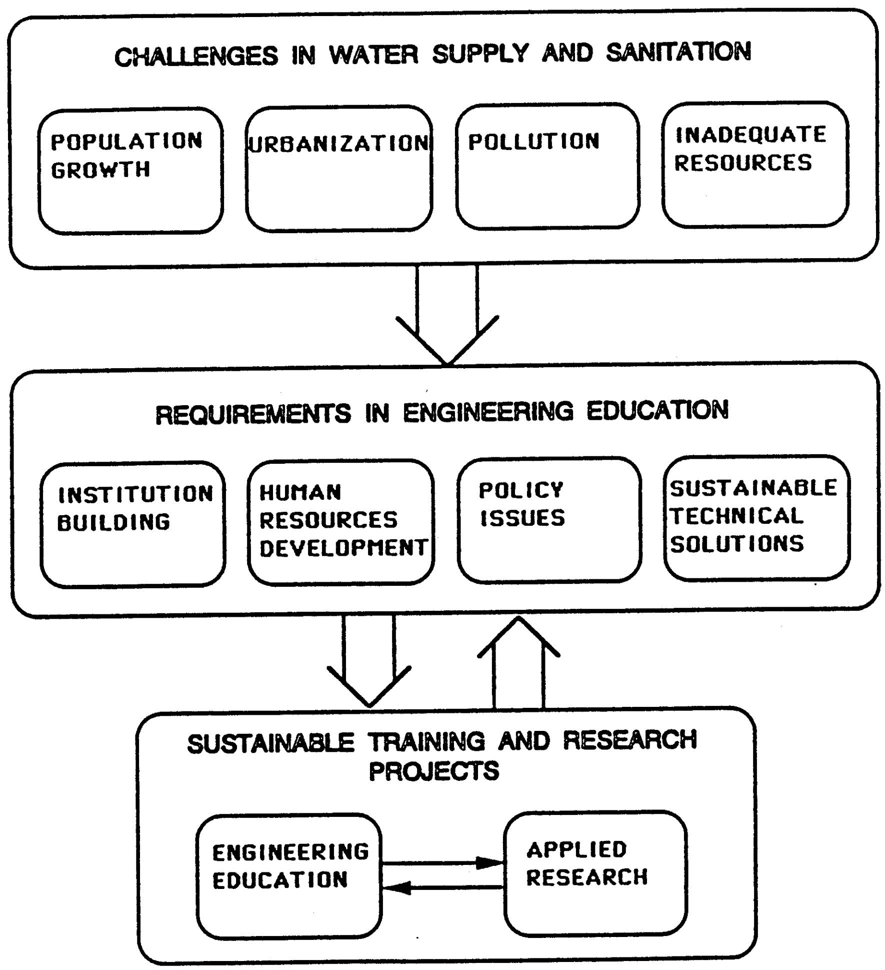

Figure 2. Challenges and requirements in engineering education

One aspect in which the engineers in developing countries should have a different balance in their education is the need to organize education and training of personnel. In developed countries there are normally proper educational institutions for various needs. But in the developing world these institutions may be missing or they do not fill the needs by quality or quantity of education and thus the people in the water sector must be active in trying to compensate the gap. (Pietilä 1992)

The contents and the approach used in engineering education have great significance in the development of water policy environment. Unfortunately, however, the curricula in many engineering education institutes do not seriously go into the issues dealing with policy questions. Too often water policy seems to be a political rather than financial and management issue.

What is needed more in the future is strong cooperation between the training and research institutions of the industrialized countries and the developing countries. Twinning has proved to be a very successful approach to training and human resources development. But in addition the institutions in the developed countries should have a closer cooperation in their educational and research activities directed to the developing countries. Comprehensive higher level curricula e.g. in environmental engineering and management or extensive research activities in the universities of the developing countries can not easily be initiated or run without essential professional support by a competent partner institution. As institution and capacity building generally does, twinning approach in training and research requires an adequately long time span to be sustainably successful.

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ENVIRONMENTAL ENGINEERING, TRAINING AND RESEARCH AT THE UNIVERSITY OF DAR ES SALAAM, TANZANIA

D.A. Mashauri

1. INTRODUCTION

The Faculty of Engineering (FoE) was established as a result of the recommendations of a working party commissioned by the Government of Tanzania in 1969 which was followed by another one in 1970. The later study, by three German consultants, culminated in an Agreement on cooperation between the United Republic of Tanzania and the Federal Republic of Germany.

The FoE is among the six faculties of the University of Dar es Salaam which are accommodated at the main campus some 13 Kilometers from the city centre. The others are:- Art and Social Sciences, Law , Science, Education, as well as Commerce and Management. The only other faculty which is not at the main campus is the faculty of medicine which is located at the Muhimbili Medical Centre (MMC). By far the FoE is the only institution in Tanzania which offers professional training in engineering at University level.

The FoE will be 18 years old this July while the University will be celebrating its 20th anniversary in August 1990. The FoE has so far (1987/88) graduated a total of 1295 engineers in the fields of civil, mechanical, electrical as well as chemical and process engineering. Additionally some 21 post graduated in M.Sc. (Eng) (mainly in Water Resources Engineering) and 2 Ph.D's have been obtained in the faculty.

The FoE is equally tooled to carry out not only its education and training task but research and consultancy which in a way forms a spring board for a sustainable technological process.

2. UNDERGRADUATE PROGRAMME

2.1 Intake

The FoE is comprised of four academic departments namely:

(i) Civil engineering

(ii) Mechanical engineering

(iii) Electrical engineering and

(iv) Chemical and Process engineering

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These departments facilitates teaching of their individual disciplinary areas while some service courses are offered to Agricultural Engineering students during their first 2 years of study at the main campus. The student intake is at present 180 students per year. They are distributed as follows in Table 1.

Table 1 Student intake per year and department in the FoE.

Discipline	No. of students
Civil Engineering	60
Mechanical Engineering	40
Electrical Engineering	20
Chemical Engineering	20
Process Engineering	20
* Agricultural Engineering	20
Total	180

* Students spend the first 2 years of their 4 years study programme at the FoE and the rest at Sekoine University of Agriculture (SUA).

The Ministry of Manpower Development is the one responsible for the intake levels according to their own manpower projections in the country.

2.2 Courses

The four academic departments have specific roles to play in the training of engineering. The following is a summary of courses taught in each department.

The Department of Civil Engineering (CE) has lion's share of the students after the common first year. The CE department comprises of three core streams, namely Hydraulics, Water and Resources and Environmental engineering, Structural engineering and

Transportation and Highway engineering. All students in this department do receive the fundamentals in all these courses and additionally they are taught construction management and site organization, building materials, soil mechanics and foundation engineering as well as building construction.

The Department of Mechanical Engineering (ME) which is the second largest department after the CE department. The ME department stresses on machine design and production engineering and introduces the students into the metal industry sector of the economy. This department has since 1983 hosted the Agricultural Engineering students for the first two years of their study the University of Dar es Salaam.

The Department of Electrical Engineering (EE) is one of the smallest departments in the FoE. The EE department emphasizes electrical machinery, telecommunication, power transmission and measurement and control engineering.

The Department of Chemical and Process Engineering (CPE) is the youngest among the others and has an intake of 40 students annually. The CPE department started in 1978 to produce engineers to satisfy the requirements of the Chemical and process industry in the country.

To complement the four academic departments a fifth department of training workshops (TW) ;is also in existence at the FoE. The TW department has two fold purposes in the FoE interalia:

(i) To provide all the students with a fundamental knowledge of technical processes and materials and basic skills in usage of equipment and machinery and

(ii) To provide specialized service to the academic departments and sections of the FoE in the manufacture of special purpose equipment, teaching aids, test rigs, prototype production etc.

2.3 Environmental Engineering

TEACHING

The course environmental engineering is taught in all academic departments at different emphases and levels according to the needs of each discipline. This section will deal with the subject from the Civil engineering department point of view.

The department of civil engineering is subdivided into 6 sections namely:

(i) Water resources, hydraulics, and environmental engineering,

(ii) Structural engineering,

(iii) transportation and highway engineering,

(iv) construction management and site organization,

(v) Soil mechanics and foundation engineering and

(vi) surveying and photogrammetry.

The first section and the largest section for that matter is the one vested with the duties to teach and research in the environmental engineering. The section teaches the following courses:

(i) Environmental Engineering I and II

(ii) Hydraulics and

(iii) Water Resources engineering.

The list below gives the environmental related courses taught in the CE department and the number of hours assigned. One thing to note here is that 242 hours are reserved for this section during the 2nd and 3rd year of study for all the students. Additionally 160 hrs are allocated for the specialized courses in the fourth year of study. The later is only for the students who opt for the water courses stream in its final year programme.

2nd year of study

CE 240 Hydraulics and Hydrology (74 hours)

Engineering Hydraulics: properties of fluids, hydrostatics, hydrodynamics, steady flow in closed conduits and introduction to unsteady flow.

Hydrology for Engineers: hydrologic cycle and its components; rainfall- runoff relations; hydrography analysis; unit hydrography; probability and statistical methods.

3rd year of study

CE340 Hydraulics Water Resources and Public Health Engineering 1(168 hours)

Engineering Hydraulics; steady flow in open channels; steady varied flow; weirs and orifices; laboratory practicals.

River and Reservoir Engineering: classification and behaviour of rivers; sediment transport; stable channel theories. Single and multipurposes reservoirs; design flood; mass curves; yield and storage determination; flood routing; useful life of reservoirs ; apportionment of costs; environmental effects, planning and operation.

Irrigation and Drainage: objectives; water requirement; soil-water relationships irrigation methods; field layouts; canals and structures.

Hydraulic machines: types of pumps and turbines; their characteristics, selection and installation.

Dams and barrages: classifications and definitions design data and criteria; embankment dams.

Rural Water Supply: demand; sources and their development; transmission and distribution systems and their components; introduction to water treatment.

Public Health: epidemiology; waste decomposition processes; sanitation without water; introduction to wastewater collection and treatment.

4th year of study

CE 440 Hydraulic, Water Resources & Public Health Engineering II

(160 hours)

Dams and Barrages: planning and design of embankment and concrete dams and barrages; construction details.

Hydropower Plants: classifications and definitions; planning and design for high-head and low-head schemes; construction details.

Water Resources Planning: Basin wise and multipurpose project planning; benefit-cost analysis; project selection; water law in Tanzania.

Water Supply: pipelines; rural and urban distribution systems; water quality and treatment; waterworks costing and economics.

Public Health: wastewater collection and storm drainage; environmental impact of wastewater, stabilization ponds.

RESEARCH

The section has very modern equipment and has competent personnel to perform research in the following disciplines:

(i) groundwater and well investigation including pollution thereof;

(ii) hydraulics model investigation;

(iii) water and wastewater treatment,

(iv) Environmental Impact Assessment as well as

(v) Solid waste management.

3. STUDENT AND STAFF STATISTICS

3.1 Enrolment

Table 2 gives the student enrolment in each year since 1973/74 when the FoE was formally inaugurated.

INPUT Students: UNDERGRADUATE AND GRADUATE ENROLMENT

Table 2 Student enrolment at FoE 1973/74 through 1988/89

Year	Undergraduate Enrolment					
	1st year[1]	2nd year[2]	3rd year	4th year	total u/g	graduate enrolment
1973/74	61	-	-	-	61	-
1974/75	89	59	-	-	148	-
1975/76	66	91	56	-	213	6
1976/77	125	67	88	55	335	13
1977/78	121	122	57	83	383	15
1978/79	140	114	103	54	411	20
1979/80	160	135	109	95	499	10
1980/81	164	155	115	109	543	8
1981/82	163	158	125	114	560	2
1982/83	169	139	129	126	563	10
1983/84	180	161	145	135	612	20
1984/85	180	169	158	140	637	5
1985/86	180	167	137	154	634	5
1966/87	192	178	121	132	612	13
1987/88	194	185	133	118	611	15
1988/89	171	171	146	119	608	15

1 including agricultural engineering students from 1983/84 onwards.
2 including agricultural engineering students from 1983/84 onwards.

3.2 Graduation

Correspondingly table 3 gives the output numbers upto 1987/88 according to departments.

OUTPUT

Student Number of B.Sc. and M.Sc.Degree Awarded

Table 3 Graduates according to department and year of study.

Disc	B.Sc. Graduates												Total B.Sc. Grad.	Total M.Sc. Grad.
	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88		
CE	28	37	24	46	63	55	53	57	56	59	63	44	585	15
ME	20	27	16	34	27	33	34	32	37	35	36	41	372	4
EE	6	13	13	11	20	14	8	17	19	21	16	16	174	2
CPE	-	-	-	-	-	11	23	29	26	39	12	17	96	-
	54	77	53	91	110	113	118	135	140	154	132	118	1295	21

3.3 STAFFING SITUATION

In order to achieve good teaching, research and consultancy work the FoE needs a healthy staffing arrangement. The members of staff are obliged to be trained to the highest level (Ph.D) so as to enhance the above mentioned tasks. Table 4, below gives staffing situation in the FoE. Part (a) of the table shows staff on post during the years up to 1987/88.

The part (b) of the table depicts the localization percentage of the posts in each department as of 1988/89 academic year. Since the attainment of Ph.D is considered the highest level of training then part (c) of the table gives the distribution of this calibre by 1988. The low numbers in some of the departments are a result of "poaching" to other institutions and countries.Of the 12 PhD's in the department of civil engineering over 60% belong to the environmental engineering section. This to some extent shows how serious the CE department and the FoE is on the environmental engineering training and research.

Table 4 STAFFING SITUATION IN THE FOE UP TO 1987/88 ACADEMIC YEAR

4(a) ACADEMIC STAFF: STAFF ON POST

Year	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88
Est	28	38	44	50	61	72	74	80	86	96	98	108	126	127	144
Tanz.	-	4	6	5	10	15	20	22	33	35	43	45	38	45	52
Expat	7	21	21	30	33	38	36	35	36	38	38	37	32	28	22
Total	7	25	27	35	43	53	56	57	69	73	81	82	70	73	74

4(b) Academic Staff: PERCENTAGE OF ESTABLISHED POSTS FILLED BY LOCAL STAFF BY 1987/88 (STAFF ON POST ONLY!)

Department	Staff Category				
	A/Lect.	Lecture	Sen. Lecture	A/Prof.	Prof.
Civil	70	60	40	0	0
Mechanical	69	57	18	0	25
Electrical	67	13	67	50	0
CPE	88	0	17	0	0

4(c) Academic Staff

Distribution of Tanzanian Staff with Ph.D by 1988 (Staff on Post Only)

Department	CE	ME	EE	CPE	Total
Numbers	12	3	7	3	25

4. Concluding Remarks

Given the status of the environmental pollution abound one cannot fail to wonder if the present curriculum at the FoE caters for this important issue.
For example the syllabus is silent on air and noise pollution while the legal obligation of the polluters is not mentioned at all. The curriculum does not mention anything on toxic wastes management and disposal or thermal pollution.

While the FoE is not supposed to teach everything on environmental issues, as some aspects will be accomplished through personal intuition and experience, but one would expect at least a mention of these issues in the syllabus.

The other aspect of environmental research is the use of e.g. remote sensing to obtain environmental data which can be used to predict and thus plan correctly. This is perhaps a field which is untapped as both personnel and equipment are lacking. But borrowing of this vital information from International agencies around us is not unfeasible proposition. It would suffice to say that there is not enough utilization of the available resources nor attempt to use it whenever available. The issues of environmental impact assessment of major projects should be discussed openly and the public involved so as not to be in awkward positions afterwards. The legalistic machinery to check environmental degradation must be strengthened in both financial and personnel sectors.

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A WATER RESOURCES GRADUATE PROGRAM IN COLOMBIA: EXPERIENCE AND NEEDS

Ricardo A. Smith, Dario Valencia and Oscar J. Mesa[1]

The Water Resources Graduate Program at the School of Mines of the National University of Colombia at Medellin was created in 1984. The primary source of funds for this program has been the university budget. For five years, starting in 1984, aid was received from a Colombian government project to develop the research capability of the major universities. This aid was in the form of equipment, money to pay visiting professors from abroad, and books.

The main objective of the graduate program is to form researchers and high level specialized engineers in the field of water resources to satisfy the country's needs in that area. Originally the only degree granted was Master of Science. Since 1991, however, one year training and Ph.D. degrees are also being granted.

Colombia is one of the richest countries in water resources and the adequate development of them is a major concern for the country. Various institutions have to undertake studies and researches such as: defining surface and ground water availability, forecasting future water demands in accordance with the country's development, defining water resources projects priorities, evaluating and proposing possible solutions to natural hazards, integrating the water resources development with the national development planning program, analyzing and making proposals to solve institutional and political conflicts for water use, integrating environmental and social aspects to the water resources decision-making procedure, to include global climatic changes when trying to analyze and understand local climatic behaviors, analyzing the rain forest man-made changes over the climatic behavior and the water resources availability of the country. The Water

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Resources Graduate Program, backed by the long-time academic and research experience of the School of Mines, is offering to the country its programs as a means to prepare high level specialized engineers to undertake the above studies and researches.

The program has been very successful, with a high number of graduate students that finished their master's degree, all of them enrolled in public and private water-related institutions, and with important contributions in research, thesis, and consulting work.

OBJECTIVES

Graduate Program Specific Objectives

Ph.D. Degree

To form researchers in the water resources field. This is achieved by integrating the Ph.D. students into research groups and by developing a Ph.D. dissertation that has to be an original contribution to the water resources field.

Master's Degree

To offer students the opportunity to gain knowledge and to be formed as researchers in the evaluation, planning and management of the country's water resources.

One-Year Training Degree

To offer students the opportunity to gain knowledge and to develop the capacity to solve specific professional problems in the water resources field.

Graduate Program General Objectives

To produce a better knowledge of the country's water resources and, at the same time, to promote their optimal planning, management and development.

To interact with public and private institutions for developing studies and research, for mutual knowledge of experiences in the water resources field.

To better prepare university teachers and researchers for developing a broad-based teaching and research capability in water resources.

To create a national scientific group with the research capability to be a major factor in the formulation and development of the main national projects. This group will also be a major factor in improving the teaching quality at the country's universities and will participate in the creation of other graduate programs in several fields.

RESEARCH AREAS

Colombia is a rich country in water resources and their adequate planning and management is a basic requirement towards national sustained development. This can only be achieved if the country has a group of highly qualified researchers in the water resources field. The graduate program is oriented to form high-level specialized engineers in one of the five graduate program basic areas and to promote applied research in each of those areas.

The five basic areas of the graduate program are:

1. Planning and Management of Water Resources: This area includes the planning, optimization, developing and management of water resources systems. It includes technical, institutional, social, environmental, economic and financial aspects.

2. Stochastic Hydrology: This area includes the probabilistic modelling of hydrologic processes in time and space, the knowledge of regional hydrologic regimes, and the treatment of the problem of working with very few and incomplete years of data.

3. Hydrologic Systems: This area is oriented to research the interaction of the water with the climate and the geomorphology of the region. The hydrologic cycle processes that affect the rainfall-runoff relationship are analyzed.

4. Ground Water Hydrology: In this area ground water modelling, surface-ground water interrelationships, and regional ground water availability are studied.

5. Hydraulics: Aspects such as hydrodynamics, sediment transport, hydraulic structures and laboratory scale modelling are studied in this area.

ORGANIZATION, RESOURCES AND RESULTS

The Water Resources Graduate Program has an academic committee and an academic head. The management of the program is done by the School of Mines of the National University of Colombia.

The program has 17 full-time teachers and researchers, all of them with Master of Science degrees and two of them with Ph.D. degrees.

There are modern computer facilities for research and teaching. Several university laboratories such as Hydraulics, Environmental, Soils, Electric, Chemistry and others, can support research done in the graduate program.

The graduate program has a specialized library and the general library of the School of Mines. In addition, libraries in other universities in Medellin and other cities of the country can be used by students.

For the Master's degree and the one-year training program the student has to attend eight academic courses (four and four elective) and two seminars. The student has to write a Master's thesis and the one year training program student has to write a final applied work. After finishing his Master's (or having exhibited equivalent or superior skills), the graduate student may be admitted to the Ph.D. program, where he has to attend two academic courses and two seminars, and write a Ph.D dissertation. The graduate program can offer a wide variety of courses (about 40 different courses) in the five basic areas of the program.

During the eight years of work of the graduate program 35 Master's theses have been completed and 15 are under development. These theses cover a wide range of research topics in the five basic areas of the graduate program. Most are geared toward applied research in order to solve specific problems or to propose possible solutions to Colombian problems. Some Master's theses are related to basic research.

About 25 research and technical projects have been developed by the professors of the program funded by several public and private institutions. The research covered a wide range of problems related to the scope of the five basic areas of the program.

Some public agencies have sponsored employees in order to do the program, which has increased the links between agencies and the program.

Two Ph.D. students started in the program in February, 1992, and are expected to finish by 1994 or 1995. Both students were incorporated with specific research topics.

DIFFICULTIES AND NEEDS

During eight years of continuous work the main difficulties and needs of the water resources graduate program have been:

1. To have or maintain Ph.D.-level teachers and researchers because of low salaries.

2. The graduate program library has great monetary difficulty in maintaining an acceptable program for buying books and water resources-related technical magazines. The books and magazines are very expensive for the program and several important magazine collections are incomplete or unavailable. Our students have to use several libraries in Medellin and Bogotá. They also depend on the friendship between Colombian graduate program researchers and researchers in the United States and Europe to ask for some references that can not be found in Colombia.

3. Although the graduate program has an acceptable computer center with a HP-9000 computer, one work station, and several 386, AT and XT compatible microcomputers, there is a lack of availability of peripheral hardware such as graphic screens, digitizer tablets, laser printers, plotters, and others. There is no access to the international electronic scientific nets.

4. Top-level software and its related training is almost nonexistent at the graduate program computer center. Software such as GIS, high-level graphics software, advanced optimization software, advanced statistical processing package, many water resources packages, satellite image processing package, and many others are unavailable. This has required the water resources graduate program to delay research in some areas because it does not have the basic tools needed. This has been very critical in the case of GIS and satellite image processing related research.

5. Although there is a national institution for research funding in Colombia (COLCIENCIAS), the amount of money that they usually expect to approve for each project is not enough for buying just a few of the above items.

6. In spite of many short visits of experts in the past, and also three month visits of program professors abroad, it is very difficult to maintain a permanent interchange program with universities and institutions abroad in such a way that our teachers and researchers can participate in training programs or in joint research efforts. This interchange is of main importance for the Ph.D. program. There are several important researches not only for Colombia but also for several countries that need joint cooperative efforts. Researches related to natural hazards, global climatic changes, and the rain forest are examples of areas for joint efforts. The water resources graduate program not only offers its staff, experience and facilities, but also the location in a strategic tropical area. Colombia has land adjoining two oceans, all kinds of natural hazards, is an important part of the rain forest, its climate is affected by some global phenomenon as the so-called "El Niño - Southern Oscillation", and many other possibilities.

PROPOSAL

There is ample evidence of the need to widen the scope of the research in water. The main problems are of much wider magnitude than the narrow view of national borders. Among the various problems of global concern, Colombia is involved and will suffer directly from the impact of tropical forest disappearance. The climatic changes produced by this and other changes man is imposing on the face of the earth will affect everyone in different ways.

The possibilities of prevention or mitigation of the negative impacts of such a major change depend on improving our knowledge of the dynamics of earth weather, and in particular the role played by water and vegetation in it. This is probably the major challenge humanity as a whole will face in the next century.

An immediate consequence of the global characteristics of the problem is the need for global response of the scientific community, through joint projects and cooperative development.

A joint research effort between the program and other water resources programs in the United States and/or Europe will help the graduate program to solve some of the difficulties stated above. This research can be in one or in several of the topics stated above (natural hazards, global climatic changes, local climatic changes, prediction and effects of "El Niño", rain forest, or other to be identified). The interchange between the water-related groups based in a specific project or a group of projects will give a special dynamic to this cooperative development. The project has to be a long-term project (around three to four years) in order to be able to adequately finish a research of this level.

SESSION VIII-C

RESEARCH IN WATER RESOURCES

ENVIRONMENTAL AND WATER RESOURCES ENGINEERING RESEARCH AT THE WATERWAYS EXPERIMENT STATION

by

F. A. Herrmann, Jr., J. R. Houston, and J. Harrison,

INTRODUCTION

The US Army Corps of Engineers Waterways Experiment Station (WES) is a six-laboratory complex that conducts the vast majority of water resources and environmental engineering research and development of the US Army Corps of Engineers. Three of these laboratories, the Hydraulics and Environmental Laboratories and the Coastal Engineering Research Center, are primarily responsible for water resources and environmental engineering.

Research within these three laboratories centers around the understanding of the fundamental fluid dynamics and transport processes governing the design and operation of inland and coastal water resources projects. From this understanding, particularly for the hydrodynamics, water quality, and transport of sediment in channels, waterways, reservoirs, estuaries, harbors, coastal zones, and hydraulic structures, the laboratories are developing a series of one- to three-dimensional modeling tools.

Highly interdisciplinary research also is performed in support of environmental quality considerations, such as the design of fish bypass systems, the development of groundwater flow and transport models, the remediation of contaminated groundwater resources, and the design and rehabilitation of wetlands.

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WATER QUALITY PROJECTS

During the past decade, WES has developed and applied a variety of numerical water quality models for coastal, estuarine, and riverine systems. In most cases, the transport terms of these models have been computed using output from numerical hydrodynamic models, necessitating a multidisciplinary team of WES engineers and scientists. WES has been very successful in the indirect linking of hydrodynamic and water quality models for application in long-term simulations (from a year to decades) to reduce the computational resources required. The recently developed Chesapeake Bay modeling system, consisting of time-varying, three-dimensional hydrodynamic and water quality models, is a prime example of this multidisciplinary approach. The system currently is being used to evaluate the effectiveness of nutrient reduction strategies for improving the water quality and health of the bay.

Development of reservoir water quality management tools at WES dates back to the late 1960's and is continuing. Current research includes identifying and describing alternative techniques for improving the in-lake and release water quality. These techniques include (1) in-reservoir alternatives to improve in-lake water quality through mixing or aeration, (2) structural or operational alternatives such as selective withdrawal from various levels within the reservoir to release desirable water and thus meet downstream requirements, (3) in-structure aeration techniques, such as autoventing turbines, (4) operational changes to aerate flow such as changing flow conditions over spillways, and (5) downstream alternatives that aerate releases to improve release oxygen.

DESIGN AND REHABILITATION OF WETLANDS

WES interdisciplinary teams are investigating hydraulic, hydrologic, sedimentation, water quality, soils and vegetation processes in wetlands. Examples of research areas being investigated include wind-wave induced growth and erosion, effects of vegetation on flows and sedimentation processes, the ability of wetlands to affect aspects of water quality, and the chemical and biological processes in the development of wetland soils. The research is being conducted through field, laboratory, and analytical investigations. For example, wave processes are being studied in the small wetland ponds found throughout coastal Louisiana. The vegetative effects on flow and sedimentation are being investigated through data collected in a bottomland hardwood wetland along the Cache River in Arkansas, as well as through controlled flow experiments at the Lewisville Aquatic Ecosystem Research Facility in Lewisville, Texas.

Besides improving the understanding of wetland processes, research is also aimed at providing techniques to predict wetland processes and their influence on wetland functions. Two tiers of modeling efforts are underway. At the first tier, numerical models are being used to enhance wetland field investigations of hydraulic, sedimentation, and water quality processes by providing spatially distributed information. At the second modeling tier, simple techniques are being developed to assist wetland scientists in evaluating wetland functions.

Forty-three demonstration sites throughout the United States are being evaluated for design criteria and engineering procedures. Specific studies include siting, circulation, and soils criteria for different wetland types. Other studies will investigate techniques for soils transport, handling and stockpiling, and techniques for plant selection, handling, propagation, etc.

Bodkin Island in the Chesapeake Bay is an example of a wetland rehabilitation project undertaken by WES. Bodkin Island had once been about 50 acres of prime black duck habitat, but over the course of years has been reduced by wind-wave erosion to less than an acre. A comprehensive restoration plan was formulated that included extensive field data collection and the use of two-dimensional numerical hydrodynamic models. A rubble-mound breakwater was designed, which incorporated a containment area for dredged material to be used in the island restoration. The design for the enlarged Bodkin Island includes shoreline stability, hydrodynamic impacts, habitat shaping, and vegetation that provides a combination of upland nesting, intertidal marsh, and tidal pool habitat.

FISH BYPASS SYSTEMS

Corps of Engineers hydroelectric projects on the Columbia and Snake Rivers have been identified as a major contributing factor to the mortality of downstream-migrating juvenile salmon (smolts). Mechanical bypass systems are used at most of these projects to collect and divert the smolts through the dam. These bypass systems incorporate large submerged traveling screens or fixed bar screens that are positioned in the intakes of the turbine units between the trashracks and scroll case.

Because there is considerable uncertainty as to the fish guidance efficiency of new screen designs, WES is using physical models to investigate flow conditions in critical areas throughout the bypass system. In addition, a field investigation is being performed at McNary Dam, Columbia River, to study smolt behavior near the screens and relate smolt impingement rates to different screen designs using state-of-the-art underwater video equipment.

GROUNDWATER MODELING AND REMEDIATION

Groundwater is the major source of water supply for over 50 percent of America's population. This precious resource is threatened by increasing amounts of contamination. Activities at military installations have produced contamination of groundwater, which may pose problems for human health and may threaten wildlife habitat and wetlands adjacent to or on these posts. Over 10,000 potential US Army hazardous and toxic waste sites have been identified.

Much of the information required for development and evaluation of economical and effective remedial measures for this contamination can be obtained using computer models. Numerical groundwater models have been developed that address specific problem areas such as flow, infiltration or recharge of groundwater, contaminant transport, dilution of contaminants, and groundwater removal. However, truly comprehensive groundwater models that adequately address all important aspects of contaminated groundwater flow and transport are needed to support remediation activities.

WES is in the formative stages of a major program for the development of groundwater modeling tools for simulating groundwater flow, the transport/fate of subsurface contaminants, and the efficacy of remedial actions. The tools will support the needs of the US Army in three main areas: site characterization, contamination assessment, and evaluation of remediation alternatives. These tools will include numerical algorithms for simulating the hydrogeologic and biogeochemical processes that must be considered when developing remediation programs for a site. An essential feature of these tools will be user interfaces that augment model application and visual presentation of results on a variety of hardwater platforms.

The primary product from the proposed research will be a one- to three-dimensional modeling system centered around both single-phase and multiphase flow in concert with single- and multiple-component groundwater contaminants. The system will be capable of simulating flows in both the saturated and unsaturated zones. Similar capabilities for numerous remediation schemes also are planned.

FLOOD CONTROL CHANNELS

In the past, the engineering approach used to address local flooding problems was to construct wider, deeper, and straighter channels. Even though conveyance objectives might have been achieved initially, such practices proved to be not only ecologically damaging, but also very short-sighted engineering. As streams tried to adjust to new artificial gradients, the beds degraded and the banks eroded, destroying whatever riparian wetlands might have been left after channelization.

An environmental engineering team approach can be used to design and construct a flood control project that provides needed conveyance and preserves or enhances environmental attributes. Besides water control structures, certain other techniques afford engineers the tools they need to accomplish these objectives. These include selective clearing and snagging (as opposed to the complete removal of in-stream woody material and live vegetation from the riparian corridor), single-bank modification, the use of low-flow channels, and the creation of slack-water habitats or other refuges of low-velocity flow. Knowledge-based systems developed at WES offer planners and designers assistance in selecting environmental features for stream channel alteration projects.

In order to evaluate the sedimentation aspects of small flood control projects, WES also has developed a computer-aided design system for use in preliminary design studies (reconnaissance and feasibility levels). The system facilitates the design of stable channels in alluvial material so that flood protection will be provided by the project throughout the project life. The system will be another major advance in channel design capability and is urgently needed due to the large number of small flood protection projects being planned. It will provide an efficient, technically sound approach for preliminary design when the project cannot afford more extensive, detailed sedimentation investigations.

HARBOR AND NAVIGATION PROJECTS

Development of the WES Ship/Tow Simulator represents a new tool for research and project studies to resolve navigation channel design and operational problems in both deep-draft and shallow-draft channels. It allows realistic simulation of the entire interrelated ship control system, thus providing more definitive guidance concerning optimum navigation channel dimensions and alignment. Simulator development has been an evolutionary process with the most recent advance being the development of a second interactive simulator to provide real-time, piloted testing of dynamic ship-ship interaction in meeting and passing. This capability is crucial in conducting credible simulation tests for projects such as the Houston Ship Channel, which involve meeting and passing operations of large-beam tankers and bulk carriers in a very restricted channel. This project is a two-stage enlargement of the navigation channel and is being supported by several interrelated studies at WES. The simulator and numerical models are being used to evaluate changes to the Galveston Bay/Houston Ship Channel system for different freshwater inflows that represent existing and possible future hydrologic conditions. Study results will be used to judge project impacts and to determine appropriate level of mitigation for the estuarine environment.

Research in support of harbor design also covers such areas as wind-wave process, ship mooring forces, and response of structures (such as jetties) to wave forces. Phased expansion of Los Angeles-Long Beach Harbors will involve new channels, basins, and landfills through the year 2020. Extensive field data on waves, harbor circulation, ship motion, and water quality have been acquired to use in operation of distorted- and undistorted-scale physical models of waves as well as two- and three-dimensional numerical models of hydrodynamics and water quality.

A major advancement in technology contributing to the design of safe and efficient navigation channels was achieved recently when WES, working with the US Army Engineer Division, Lower Mississippi Valley, developed the bendway weir design concept to correct navigation problems at two problem Mississippi River reaches. The design involves a series of upstream-angled, level-crested, submerged rock weirs built around the bend to widen the navigation channel, improve flow distribution, and eliminate most of the dredging. Because the weirs are submerged at depths allowing the passage of tow traffic at all flows, they also preserve the waterway's natural beauty.

SUMMARY

WES engineers and scientists are involved in a wide variety of water resources research and project investigations of the Corps' Civil Work Missions and Army military activities. Most of these studies are interdisciplinary. Studies typically consist of research into engineering and environmental processes, development of new analytical and modeling tools, and investigations of site-specific projects (planning, design, operation, and maintenance). These studies are frequently supported by activities related to the development or application of scientific visualization, Geographic Information System (GIS), and remote sensing.

ACKNOWLEDGMENTS

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USE OF GIS IN STUDYING WATER MAIN BREAKAGE PROBLEMS

Emmanuel U. Nzewi[1] and Subhasis Mukherjee[2]

ABSTRACT

A case study of the water main breakage problem in the City of Greensboro, NC is presented. An analyses of water main breakage data complied by the City was performed. Hypotheses pertaining to the relationship between certain measurable phenomena and water main breakage frequency were tested. A model for predicting breaks from the limited data studied is presented. The use of Geographic Information System (GIS) technology to study the water main breakage problem is proposed and the benefits of implementing a GIS to study the problem are briefly discussed.

INTRODUCTION

The problem of water main breakage is faced by public works departments in cities around the world. This paper presents a case study of the failure trends of water mains in the City of Greensboro in central North Carolina. This study was initiated at the request of the City's Water and Sewer Department. It is hoped that a better understanding of the pipe breakage phenomenon would be prtovided so that the Department can develop better water main maintenance strategies.

A lot of work has been done to forecast the frequency of breakage (Shamir and Howard, 1979). Some of the work in this area address the water main breakage problem by developing schemes to forecast breakage through statistical analyses (for example, regression) of historical data. On the other hand, other studies have provided discussions of the causes and types of water main breaks. For example, in a study reported by the New York District of the Corps of Engineers (US Army Engineer District, 1980) several causes of water main breaks in cast iron pipes were presented including: soil movement, impact, temperature, corrosion, improper laying, and various combinations of all of the preceding. It has also been found that more frequent pipe breakages are reported in the winter months. This is highlighted by that fact that when the soil is highly permeable, severe winters can result in deep frost penetration. Increased soil movement and loads on pipes occur when the soil freezes. In a study, Smith (1976) showed that the loads on a pipe can double when frost penetrates close to the top of the pipe.

In Great Britain, the Standing Committee on Water Sewer Mains (1976) published reported life expectancies of pipelines ranging from 40 to 100 years for calculating depreciation. In another study, Clark et al. (1980) determined that the

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age of metallic pipes (cast iron and steel) was important in determining the time elasped to the first repair and in the frequecy of breaks. It was also determined that the corrosivity of the soil, pressure in the pipe, and land use practices were important factors which affected the breakage rate. Romanoff (1964, 1968) and Gerhold (1976) have reported that there is loss of weight and pitting in metallic pipes over a period of years (as the pipes age) which depends on the soil environment. These studies explain the increased rate of pipe breaks with age which is attributed to strength reduction resulting from corrosion. Fitzgerald (1968) showed that corrosion-induced breaks increase exponentially over the life of a pipe, while breaks resulting from other causes do not vary greatly with pipe age. Published statistics of water main break data show that the number of breaks per unit length vary widely from city to city. Another approach to the pipe breakage problem is to develop pipe replacement strategies based on several measurable criteria (Stacha, 1978; Lane and Buehring, 1978).

Another aspect of the water main breakage problem is that a failure needs immediate attention because the period of loss (or degradation) of service has to be minimized. Hence the speedy the assignment and deployment of a maintenance crew is desirable. The time required to assign and deploy a crew is significantly reduced if a crew is assigned (on stand-by and stationed close to) to a zone or area of a potential break. Because of this, the pipe breakage problem is addressed here by determining patterns of failure which include their frequency and the probable location of failure. A facility location problem approach was used in a related study to determine the optimal location of a maintenanace crew. Finally, ascertaining a trend in the breakage rate helps in the long term rehabilitation planning of a city's water distribution infrastructure -- especially in determining projected year-round manpower requirements and replacement costs.

COMPILATION AND ANALYSIS OF BREAKAGE DATA

The City of Greensboro maintains a Water Main Failure Report for every reported breakage incident and therefore the data for this study was already compiled. Unfortunately, the data was not maintained in digital format. Each failure report included the following information: the location or address of the break, the date and time the break was reported, the type of pipe involved, the size (diameter) of the pipe, a description of the failure mode, the apparent cause of the break, the type of soil, the repair time and labor requirements, and the repair date. Other descriptive information can be included in a report. In order to understand the spatial distribution of the breaks, the City was divided into fourteen (14) zones, each zone comprising of sixteen (16) blocks. The zonewise breaks were tabulated by month. The reported water main breakage for each year were grouped according to the established zones and the total number and percentage of total occurrences in each zone were calculated. This analysis was performed for six consecutive years (1986 through 1991). In all, over 8,000 pieces of data were analyzed. The most tedious aspect of the project was locating the breaks on the map and grouping them into the established zones. It is intersting to note here that if a Geographic Information System were used, this exercise could have be easily automated and many more data points may have been considered. It was discovered that both the yearly total number of breaks for the city and the yearly zonewise distribution of the breaks were statistically uniform over the six-year period studied. Further analysis revealed that more than 70% of the incidents occurred in only five (5) of the fourteen (14) zones. Futhermore, a strong correlation between a function of the average air temperature and the number of breaks was also established. See Figure 1. Next, the "zoning" technique was used to further analyze the five (5) zones in which most of the breaks occured in order to identify "trouble" or high failure subzones. This procedure can be repeated until the subzones are "sufficiently" small so that effective crew deployment and/or rehabilitation decisions or recommendations can be made.

The plot of monthly breakages shown in Figure 1 indicate that the breakage phenomenon is seasonal. The superimposed temperature function also shows a relationship between breakage frequency and temperature. The seasonal trend shows that there are higher faillure rates in the winter months as opposed to the lower rates in the spring, summer and fall months. The seasonality of the failure rates was used to develop a forecasting model. The model is a classical horizontal seasonal model which needs at least two years of lead time data for the calibration of its parameters. In the implemetation of the model, two smoothing parameters α and γ ($0 \leq \alpha \leq 1$; $0 \leq \gamma \leq 1$), must be chosen first. The parameter α is used to determine the model estimates of the monthly "demand" (breaks) parameters and γ is used to calculate the the seasonal (monthly) ratios of the breaks.

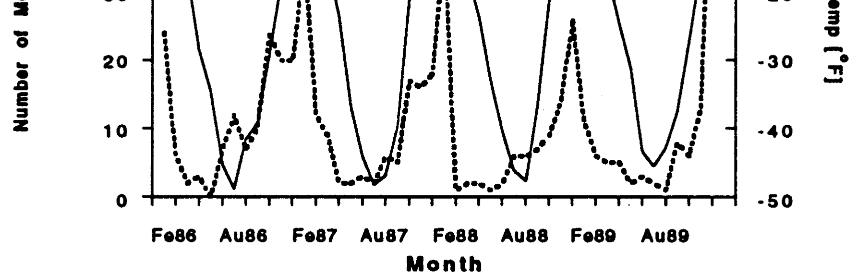

Figure 1. Monthly Breakages and Temperature Function.

The performance of the model is presented in the plots comparing predicted and actual breaks. Because the effect of temperature fluctuations was ignored in this model, its performance in periods of wild fluctautions in temperature is poor. For example, in December, 1989, when Greensboro experienced an unusual freezing spell, the model performed very poorly. It is hoped that in a future study, a temperature component will be included in the forecasting model.

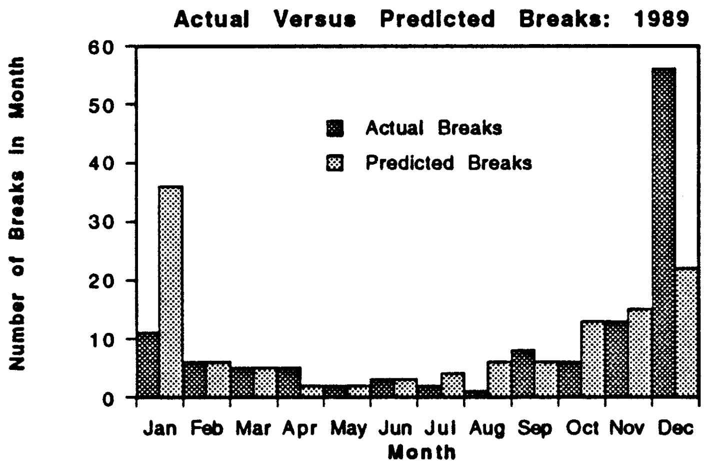

Figure 2a. Actual and Predicted Breakages for 1989.

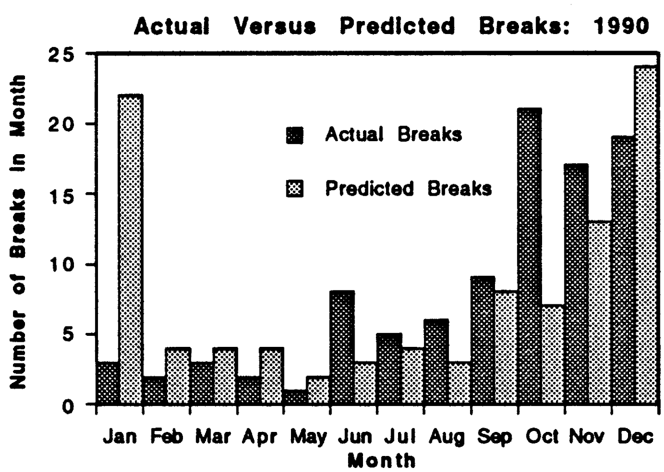

Figure 2b. Actual and Predicted Breakages for 1990.

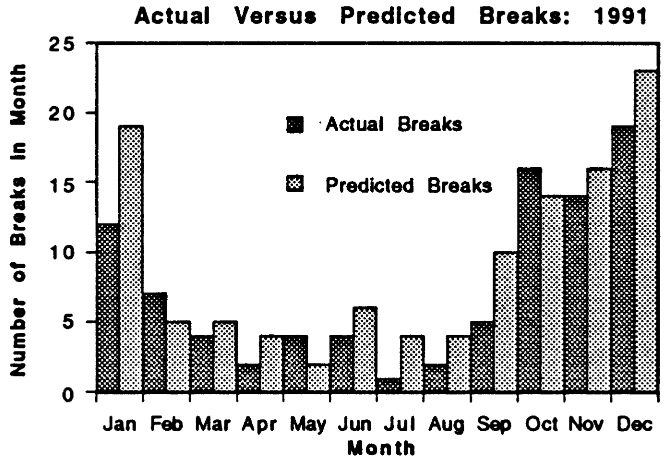

Figure 2c. Actual and Predicted Breakages for 1991.

USING A GIS TO STUDY WATER MAIN BREAKGE

Because of the spatial nature of the water main breakage problem, the large amounts of data that needs to be included in any meaningful study, the zoning technique used in the study described here, and the ability to automatically locate (geocode) a failure on a map, the use of Geographic Information System (GIS) to further explore this problem is proposed.

A GIS is an information system which can be used to collect, store, retrieve, analyze (explore relationships, identify locations by criteria, etc.) information based on its spatial attributes. Geographic Information Systems depend upon the proper intergration of three distinct aspects of computer technology. These are: the management of graphic and non-graphic data (Database Management), submodels for displaying, plotting and manipulating graphic representations of data, and analysis tools that facilitate spatial analysis. Interest in GIS technology has increased very significantly in the last few years due to improvements in computer hardware and software technology and the successful integration of these distinct technologies at reasonable costs. Antenucci, et al. (1991) provide an excellent overview of the technology and also present several examples of the successful implementation of this technology.

With regard to the pipe breakage problem, several advantages of using a GIS can be pointed out. These include: automatic address matching (geocoding of the breaks); ability to manage large amounts of data very efficiently; ability to perform several types of spatial analyses and queries -- including the identification of high failure zones, superimposition of land use practices and zonal failure frequencies, thematic maps showing zonal failure rates per unit length, etc; and the ability to generate reports -- to mention a few.

In the developement of the GIS, a base map for the City of Greensboro is needed. Other data including information about the water distribution network for the City, the street network, the soil classification data and other urban data including demographics. The address data will be used to perform the street networking exercise so that the geocoding of the pipe breakage data can be automated. A database, similar to the one used in this study can then be integrated into the system. Next, the analyses tools needed for the pipe breakage study can be developed and customized to provide the information needed for the management of the City's watermain infrastructure.

SUMMARY

Based on the preliminary study described here, it has been shown that a zoning technique can be used to obtain vital information necessary for the development of water main rehabilitation strategies. The use of GIS to efficiently manage and analyse pipe breakage data has also been discussed. An overview of the procedure for the implementation of a GIS was presented.

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SESSION IX-A

WATER RESOURCES AND ENVIRONMENTAL EDUCATION

Environmental Engineering Education by the Video Classroom

David G. Parker

INTRODUCTION

The College of Engineering of the University of Arkansas is the only institution in Arkansas offering graduate engineering education, and the only Civil Engineering Department in the state is located on the Fayetteville campus in the northwest corner of the state. In an effort to provide for graduate and continuing education throughout the state, the Graduate Residence Center for Engineering (GRCE) was established in Little Rock in 1986. The center offers graduate engineering courses by video tape at four locations within the state and at several industrial sites. Students taking courses through the GRCE take the same courses and receive the same credit as students on the main campus at Fayetteville. Through this program, practicing Engineers can take individual courses for continuing education or can pursue a program leading to the Master of Science degree in Engineering.

The Civil Engineering department is an active participant in the GRCE program, and the major portion of the Civil Engineering contribution involves environmental engineering course offerings. Some of the environmental engineering courses that have been offered to date include Advanced Wastewater Process Design and Analysis, Stream Pollution Analysis, Public Health Engineering, Solid Waste Engineering, Water Treatment and Distribution System Design, and Advanced Pollution Control. Currently there are nine students enrolled in the program that have declared a primary interest in an environmental emphasis. Present and past environmental students are associated with a wide variety of public and private organizations including the Arkansas Department of Pollution Control and Ecology, U.S. Army Corps of Engineers, Arkansas Soil and Water Conservation Commission, and private industry and consulting firms.

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VIDEO INSTRUCTION

Classes in the GRCE program are presented as videotaped lectures. The approach used is the 'candid classroom' concept in which classes are videotaped at the same time the class is offered on the Fayetteville campus. Tapes recorded on the Fayetteville campus as well as printed materials such as handouts and exams are sent weekly to the GRCE site locations. During each GRCE class, site coordinators at each location set up the tapes, hand out materials, and collect homework. The tapes may also be viewed at other times for the convenience of the GRCE students who may have to miss the evening session because of demands of work. Students may also choose to review the tapes a second time for some of the course material. Faculty may visit the off-campus locations during the semester and are available by telephone during regularly scheduled office hours.

VIDEO CLASSROOM

The video production facilities used for GRCE courses are located at the College of Engineering on the Fayetteville campus. The facilities consist of a classroom studio and a control room. The classroom is equipped with three industrial quality video cameras, wireless microphones and a special monitoring system, all of which are controlled by a Production Technician located in the control room. The Production Technician can use a variety of on-line aids to record the classes, including slides and computer-generated graphic displays. One of the video cameras in the classroom is mounted overhead so that any material that the instructor places on a custom-built podium can be recorded and also simultaneously displayed during the lecture on two large monitors mounted at the front of the classroom. The podium contains a variety of equipment including controls and monitor for the overhead camera, a monitor showing what is actually being recorded, and a two-way setup for communicating with the Production Technician.

FACULTY TIME

The amount of extra time required by the faculty involved in video classes varies depending on the individual and the nature of the material being presented. Most faculty report that video classes are much more time consuming and may require as much work as up to two regular classes. The extra time requirements are for visiting the off-campus classes, answering telephone questions, and preparing special course materials and handouts. The author has found that the preparation of special course materials is the most time consuming part of preparing for the video classes. Class notes including text, figures, and calculations are prepared with special care before class so that they are easy to see on the monitors at the remote locations. In addition to being projected on the monitors, all notes are copied and handed out to the off-campus students before each class.

IMPRESSIONS OF THE PROGRAM

Most of the students at the remote locations seem to be favorably impressed with the quality of the program and are glad to have the opportunity to take the same classes that are taken by the Fayetteville students. However, some students have voiced complaints about the lack of interaction with the instructors and an occasional delay and/or mixup in sending materials between Fayetteville and the remote locations. The performance of the students at the remote locations tends to be more variable than performance of the Fayetteville students. It is not unusual for the remote students to have both the highest and the lowest grades in a class.

The following are seen by the author as the advantages and disadvantages of the videotaped approach to providing continuing education in environmental engineering to remote locations.

Advantages:

(a) Off-campus courses are the same as on-campus courses.

(b) Tapes are available for viewing at times other than the regularly scheduled classes.

(c) Classes can be presented to many students at a variety of locations.

Disadvantages:

(a) A large investment in production equipment and staff is required.

(b) Interaction between faculty and students is reduced.

(c) An increase in faculty preparation time is required over conventual classes.

(d) It is difficult to incorporate laboratory experience in this kind of program.

In general, the author feels that the video program has been successful because it has allowed many practicing engineers throughout the state to take environmental engineering classes without interrupting their careers. Future plans for the GRCE program include increasing the number of course offerings, increasing the number of off-campus locations, and possibly adding satellite transmission capabilities.

Groundwater Contamination and Remediation: A Module of Instruction

Bradford H. Spring[1]

ABSTRACT

This paper reports a first attempt at including an instructional module dealing with toxic waste remediation in the required environmental engineering course sequence taken by civil engineering students. The instructional unit included four lectures presented by a staff engineer with Canonie Environmental Services, Inc., and three laboratory exercises planned and managed by full-time faculty.

The lectures ranged from basic concepts such as chemical partitioning to remediation systems. A case study was presented in detail. The guest speaker created, assigned, collected, and graded two sets of homework problems dealing with soil flushing. Short video tapes efficiently showed remediation at work in the field.

The first lab included a review of selected groundwater flow concepts and use of a small flow table to visualize contaminant plume migration, unwanted plume capture by a water supply well, and purposeful plume capture with a remediation well. The concept of a slurry trench cutoff wall was presented in the second lab session, followed by the construction of a tiny slurry trench by each student group. Then the entire lab group completely enclosed a "contaminated" site with a slurry wall, designed, mixed, and placed the backfill, and lowered the water level inside to attain an inward hydraulic gradient. The third lab made use of a "mystery box" (sand box) to help focus student attention on field conditions, particularly the need for detective work to locate pollutant sources, the extent of pollutant migration, and the concentration contours. Some emphasis was placed on budget constraints, on planning, on "chain of custody", and on sampling techniques.

The paper focuses on the laboratory aspects of this instructional module.

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INTRODUCTION

Threats to the groundwater system from toxic materials have filled the popular and scientific media for a number of years. The "sins of the past" have come to haunt us. Investigation and cleanup of the thousands of contaminated sites will be a drain on our nation's financial resources for the foreseeable future.

Civil Engineers (along with other disciplines) are commonly involved with the investigation and remediation of contaminated sites. Since a substantial number of CE graduates (BSCE) are finding employment in this area, and since the contamination problems are likely to persist for many years, some revisions in the CE curriculum seemed justified. What follows is an explanation of a module of instruction which was introduced into the first required environmental engineering course at Valparaiso University. This "house" was chosen for the "toxic module" to insure that all CE seniors would be included and to have a home for the lab sessions. Environmental Engineering I follows Hydrology and Fluid Mechanics, and in turn is followed by Environmental Engineering II.

The "toxic module" (fall semester 1990) consisted of 4 lectures and 3 lab sessions. The lectures were conducted by a recent BSCE graduate who has been working with Canonie Environmental Services, Inc. since graduation. He presented an overview of toxic waste remediation, and explained, assigned, and graded homework dealing with partitioning (soil flushing). (EPA (1989) includes a list of soil-water partition coefficients.) Also, a completed project was presented in detail as a case study. Short video tapes efficiently showed remediation at work in the field. The three labs were devised and conducted by full-time CE faculty. **The rest of this paper focuses on the lab sessions.**

THE SLURRY WALL LAB

The slurry trench cutoff wall technique has been used for construction purposes for decades. In recent years this technique has also been used to develop hydraulic confinement around certain toxic waste sites. The slurry wall approach interested the author, seemed important, and offered an opportunity for a down-to-earth laboratory session.

Slurry Wall Phase I

In phase I, the class was divided into groups of two students to work with clear plastic boxes, 4.5" square by 8" high and open at the top, initially filled nearly to the top with dry beach sand. Each student group prepared a 4% bentonite slurry and then simultaneously excavated a trench along one wall of the box while "pumping" in slurry to support the unconsolidated granular material. The slurry supported the vertical sand wall beautifully and the clear plastic allowed visibility of that support along two edges. In that loose sand does not stand up well by itself, the students were quite impressed by the ability of the slurry-filled trench to provide stability.

Using P.P. Xanthakos (1979) as a reference the students calculated the stability of the slurry trench and also noted that sufficiently high groundwater elevation would cause problems. By gradually raising the groundwater level in the sand which filled their plastic box, each group caused their slurry-supported trench to collapse. While measures can be taken in the field to deal with high groundwater, the purpose here was to clearly show the negative impact of high groundwater on the stability of the slurry trench.

Slurry Wall Phase II

Next all of the students worked together with one pan approximately 24" square by 8" deep also filled with beach sand. The effort now focused on immobilizing a presumed toxic plume at the center of the pan with a hydraulic barrier wall. One group mixed slurry while another excavated sand and filled the excavated space with slurry until a trench was constructed completely around the supposed toxic plume at the center, leaving a space about 8" cubed inside. Meanwhile a group was designing, mixing, and preparing to place "impermeable" backfill (excavated material + local clay + some bentonite). As the backfill was "dumped", bentonite slurry was displaced from the trench, collected, and placed in a holding tank. (The slurry's only purpose is to temporarily support the trench walls until the backfill is placed.)

The entire site was then saturated with "groundwater". The effectiveness of the hydraulic barrier was demonstrated by depressing the groundwater level inside, thus creating a "negative" hydraulic gradient as might be used to confine an actual toxic plume. While some seepage still occurred along the rough steel bottom of the container as well as through any "windows" in the backfill, the flow rate was orders of magnitude smaller than it would have been with sand alone.

Improvements

In the fall of 1991 the students placed a clay layer at the bottom of the steel pan prior to filling the pan with sand. During the excavation of the trench a key (notch) was then excavated into this clay layer to reduce the seepage which sneaks along the bottom of the pan. The improvement is realistic in that field-constructed hydraulic barrier walls likewise tie in with the lower confining layer. Also, the seepage rate was measured and the coefficient of permeability of the barrier wall was calculated.

CONTAMINANT MIGRATION "LAB"

A small Hele-Shaw type flow table, 2' wide x 3' long, was set up with flow parallel to the long dimension to represent groundwater flow responding to a sloping water table. Dye was used to mark one or more trajectories which might indicate plumes of contaminated material. Near the center of the table are a series of ports, along the centerline and perpendicular to the centerline, which may be used to withdraw water (pumped well) or admit water (recharge well). The impact on the dye trajectories was then observed with one or more ports operating either in the pumping or recharging mode. The plumes may be captured or partially captured or pushed away (and in the process contaminate new territory). Bedient and Huber (1988), among others, define the "capture zone".

Flow visualization was a primary goal for this lab. Another goal was to review the groundwater hydrology concepts learned a year earlier and then to apply those concepts to the determination of the time of flow along a trajectory starting some distance upstream and laterally displaced from a pumped well. Each student was assigned a different lateral starting point for the specified combination of uniform flow and radial flow toward the pumped well. Most of the students had trajectories inside the capture zone while some were outside. Time to flow from the starting coordinate to the vicinity of the well was determined. A spreadsheet program, such as "Quattro", makes this a reasonable problem and provides graphical output.

Proposed Improvements

A feature which might be added to this lab is the dispersion of a plume which occurs with distance. In that no porous medium was present in the flow table, dispersive effects were minimal. The author is contemplating the use of some light colored sand in a separate "channel" of greater length to illustrate dispersion. Although the results may be sensitive to the particular dye used, so might field results be sensitive to the particular contaminant present due to the wide range of values of partitioning coefficients.

THE MYSTERY BOX LAB

Using 2"x 12" planks and several layers of 4 mil plastic a water-tight enclosure was formed with dimensions of 6' x 9' x 11" high. Mortar sand was placed in 2-3" layers and compacted uniformly by repeatedly dropping a concrete block from waist height. Across the 6' ends of the tank gravel was placed to form a headbox and a tailbox and was separated from the sand by geofabric. (The gravel was just a simple way to provide support for the sand and also allow enormous permeability.) Water was then admitted to the box slowly from the bottom with the hope that most of the air would be displaced upward by the slowly advancing water front.

To establish a uniform flow, tap water was admitted at one end with a garden hose and pumped out of the other end to waste. Both flows were measured and adjusted to near equality. The flows were set about two hours before the beginning of the lab to give sufficient time to establish steady flow in the system.

Groundwater Flow

The first lab actions were aimed toward a review of groundwater flow. The students were instructed to measure the inflow and outflow (beaker and timer). Next they measured the level in each of 5 observation wells (pieces of 1.5" diameter plastic pipe). The tops of these standpipes were square, smooth, level, and all at the same elevation. Water levels were easily determined relative to the tops and then compared. After determining the saturated thickness of the "aquifer", and after referring to the hydrology text, the hydraulic conductivity was calculated. Also, the time to flow was calculated using an estimated porosity value.

"Toxic Investigation"

Given a scenario regarding previous land use and "sick cattle" the lab group was asked to form a plan of investigation for groundwater contamination. The first phase involved sampling from the **existing** monitoring wells and the gravel areas at each end. Contaminant (salt) had been placed within the flow field earlier in the day by the instructor and carefully concealed. The testing for contaminant then became one of measuring the conductivity of each sample. At this time several teams were formed: surveyors, drillers, samplers, testing lab, and quality control.

The second phase was based on the results of the initial sampling. Cost was introduced as a factor by limiting the lab group to a maximum of six new monitoring wells at locations of their choice. By the end of the lab the students had essentially located the contaminant source.

SUMMARY

As an introduction to groundwater contamination and remediation, the Toxic Module described above is felt by the author to be effective.The Toxic Module, along with Air Pollution and Solid Waste modules in the second environmental course in the spring semester helps to provide a more balanced introduction to the field of environmental engineering (i.e. going beyond the traditional "water and wastewater" topics).

The module of instruction herein described is presented, not as a model for another university, but rather as the method chosen by the Civil Engineering faculty at Valparaiso University to augment their Environmental Engineering program. Each school has a unique set of constraints and must arrange their program accordingly.

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MINTEQA2 AS A CHEMICAL SPECIATION MODEL FOR USE IN SOIL AND WATER INVESTIGATIONS

W. L. Lindsay[1]

BACKGROUND FOR CHEMICAL SPECIATION

Measurements of total elemental concentrations in natural waters and soils are key factors in determining mobility and transport relationships. It is also important to be able to partition total elemental concentrations into specific ion activities and to calculate ion activity products. Without this additional information, measured solubilities remain empirical and can not be compared to the vast amount of solubility data accumulated on known minerals reported in the literature. Modern computer technology and software programs are now available that can readily calculate ionic activities and ion activity products of known minerals. With this information the solid phases controlling elemental solubilities can be identified and used to predict changes that are expected to occur when environmental conditions change.

Problems Using the Chemical Equilibrium Approach

Inductively couple plasma (ICP) is a convenient tool for determining the analytical concentrations of many elements in waters and soil extracts. Upwards of 20 or more elements can be determined simultaneously. Unfortunately, the concentrations of several important elements are below ICP analytical detection limits. In special cases chelation methods can be used to raise total metal concentrations without significantly changing the activity of a target metal ion. The activity of the target metal ion can then be calculated from the concentration and activity of one additional chelated metal.

Another serious problem in calculating metal ion activities from total elemental concentrations is the presence of organic complexes that can not be

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identified, measured, or expressed in terms of equilibrium constants. If soluble organics can be separated from inorganics, then chemical speciation can be used to speciate successfully the inorganic fraction. The chelation method discussed above can also be used to raise total metal concentrations and thereby minimizd the contribution of organic complexes.

Another challenge in using chemical speciation models is to develop and test equilibrium constant data bases that are specially designed for use with natural soils and waters. Over the past several years we have worked to develop such a data base. This data base can be easily modified and substituted into MINTEQA2. This easy exchange will encourage many scientists to cooperate in selecting and testing equilibrium constant appropriate to soils and waters.

Objective:

The purpose of this paper is to show that MINTEQA2 can be installed in a desk-top computer and used successfully to speciate the solution phase of soil and water systems. The procedure used for installing a modified equilibrium constant data base is also presented. Examples of how MINTEQA2 can be used to examine different kinds of chemical equilibrium relationships are included. A demonstration session will be provided for those who are interested.

INSTALLATION AND OPERATION OF MINTEQA2

The chemical speciation model MINTEQA2 was developed by EPA, Athens, GA (Allison, et al. 1991). Version 3.11 was released in December 1991 and was the version used in the development of this paper. More information on the development and use of this software program can be obtained from the Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency Athens, Georgia 30613, telephone no. (404)546-3594.

MINTEQA2 can be installed on an IBM-compatible desk-top computer using the following procedure:

1. Insert the disk containing MINTEQA2 Ver. 3.11 program into drive A:
2. Type A:\INSTALL, press the <enter> key and

follow instructions from the screen.

To replace the equilibrium constant data base furnished with MINTEQA2 Ver. 3.11 with the current version of our Modified Data Base, proceed as follows:

1. Insert the disk containing the Modified Data Base into Drive A:
2. Type COPY A:*.* C:\MINTEQA2 and press <enter> key.
3. Type DEL THERMO.UNF and press <enter> key.
4. Type DEL TYPE6.UNF and press <enter> key.
5. Type UNFRMT and press <enter> key.

For routine operation of MINTEQA2 proceed as follows:

1. Turn on the computer and change the default to the C:\MINTEQA2 directory.
2. Type PRODEFA2, press the <enter> key, and answer the questions which will assist in defining the problem and entering input data.
3. Type MINRUN and press <enter> key to carry out the calculations.
4. Type PRINT XXX.OUT and press <enter> to print the output file.

EXAMPLE MINTEQA2 APPLICATIONS

Numerous applications could be devised to demonstrate the usefulness of MINTEQA2 for examining chemical equilibrium relationships of soils and water (Lindsay and Ajwa, 1992). MINTEQA2 is currently used for teaching the graduate course, AG 560/C560 Chemical Equilibria in Soils at CSU. Examples given below are aimed at helping potential users get acquainted with MINTEQA2 and the interesting things that it can do.

Hydrolysis of Al^{3+}

Use MINTEQA2 to prepare an activity diagram showing the log Al^{3+} and its hydrolysis species in equilibrium with $Al(OH)_3$ (gibbsite) over the pH range of 4 to 8.

Proceed as follows: Consider gibbsite as an infinite solid and use the sweep option to fix pH at three values: 4.0, 6.0, and 8.0. Execute MINRUN to complete the chemical speciation of the three systems. Included in the output for each pH value are the activities of Al^{3+} and each of the hydrolysis species. These parameters can readily be plotted as requested. Similar examples could be used for other metal ions and the solid phases controlling them. Inclusion of a low level of neutral salt such as 10^{-7} M NaCl is often beneficial for increasing the degrees of freedom and avoiding simple phase rule violations.

Multiple Aluminosilicate Weathering

Determine the equilibrium pH and log F^- activity that would result from the simultaneous weathering of kaolinite, montmorillonite, chlorite, fluorphlogopite and soil-Fe, when the activities of Mg^{2+}, and K^+ attain approximately 10^{-3} M.

Begin by declaring the following as infinite solids: kaolinite (8603001), Mg-Montmorillonite (8646006), chlorite (8646007), flurphogopite (8646008), soil-Fe (2028103), and fix the activities of F^- and Mg^{2+} at 10^{-3} M. The numbers included here are used to identify the solid phase minerals included in the MINTEQA2 data base. Execution of MINRUN completes the chemical speciation of the equilibrium solution.

The speciated output shows the equilibrium pH to be 7.38 and the log F^- activity as -5.95. Equilibrium is verified for all the solids shown above by the log saturation index value of 0.000 indicating the ion activity products in solution exactly equals the log K^o or equilibrium constant for that solid included in the MINTEQA2 data base. Similar examples can be generated using different minerals and weathering environments.

Calcium Carbonate Equilibrium Relationships

Prepare a plot of log Ca^{2+} activity vs. pH to show how the solubility of calcite is affected by different partial pressures of CO_2 and additions of acids, bases, and salts.

One approach to solve this problem would be to use PRODEFA2 and the multi-problem generator to define seven systems each of which contains infinite solid phase $CaCO_3$ (calcite). The first four systems could have different partial pressures of CO_2, that is, 1)

0.0003, 2) 0.003, 3) 0.03, and 4) 0.3 atm. (atm x 101.3 = kPa). The latter three systems could have the same CO_2 (0.0003 atm) but each receive 0.01 M additions of either 5) HCl, 6) NaOH, or 7) $CaCl_2$, respectively. Execution of MINRUN provides the speciated equilibrium solution for each of the seven $CaCO_3$-saturated systems. The results can be readily plotted as requested.

EDTA EQUILIBRIA IN SOILS

Use MINTEQA2 to predict the equilibrium distribution of metal ions on the chelating agent EDTA (ethylenediaminetetraacetic acid) in two different soils: A) an acid soil of pH 6.5 and B) a calcareous soil of pH 8.0.

This problem can be approached by selecting those ions most likely to be chelated by EDTA and the solid phases that are most likely to control the activities of those metal ions. From the work of Lindsay (1979), the most likely competing metal ions for the EDTA chelating ligand in well-aerated soils are Ca^{2+}, Mg^{2+}, Fe^{3+}, Al^{3+}, Mn^{2+}, Cu^{2+}, and Zn^{2+}, and the most likely solid phases controlling these cations are soil-Ca (2015002) or calcite (5015001), soil-Mg (2046002), soil-Fe (2028103), kaolinite (8603001)-quartz (2077002), $MnPO_4 \cdot 1.5H_2O$ (7047003)-βTCP (7015006), soil-Cu (2023103), and soil-Zn (2095007), respectively.

Use PRODEFA2 to fix pH at 6.5 for the acid soil and fix pe+pH at 15.0 to represent a well-aerated soil. Enter each of the above solids as an infinite solid. Enter EDTA at an arbitrary concentration of 10^{-4} M. For the calcareous soil prepare a second input file by altering the input file of the acid soil by changing pH to 8.0, pe to 7.0, deleting soil-Ca, fixing calcite as an infinite solid, and fixing CO_2 at 0.0003 atm. to represent atmospheric CO_2. Execute MINRUN.

The output from MINTEQA2 gives a complete chemical speciation showing the concentrations and activities of all solution species, the mole fraction distributions of the components, and the log saturation index of solid phases. The equilibrium mole-fraction calculations of metals on EDTA for the two soils are shown below. It is apparent that the metals chelated by EDTA change very significantly with pH. Changes that lower the activity of one metal ion relative to others cause more of the first metal to be chelated and vice versa. The chelation of metals in the two example soils shown below and demonstrate the importance of pH in metal chlelate equilibria in soils.

Calculated Mole Fraction of Metals on EDTA

Metal	Soil pH 5.6	Soil pH 8.0
Cu	10.5	0.0
Zn	57.7	1.3
Ca	4.3	49.5
Fe	26.7	0.0
Mn	0.0	48.3
Mg	0.0	0.0
Al	0.0	0.0

SUMMARY

Chemical speciation is a powerful tool for partitioning total elemental concentrations into specific ionic activities. This paper shows how the chemical speciation model MINTEQA2 can be used with a desk-top computer to carry out such calculations. Examples are given to demonstrate the wide flexibility that MINTEQA2 has in addressing different kinds of problems and questions. A demonstration will be given following the presentation for all interested persons.

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SESSION IX-B

INTERNATIONAL CASE STUDIES

Small Dams in Africa: Health Impacts

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BACKGROUND

Problem Description. Economic development in Africa requires the control of water resources for irrigation purposes in arid environments. However, small scale irrigation projects may be accompanied by negative health impacts for several reasons. First, the extension of a year round supply of water in dam reservoirs improves and expands habitats for disease spreading hosts and vectors of parasitic diseases. Second, proximity, lack of safe and convenient drinking water supplies, inadequate sanitation, and poor hygiene practices result in increased human exposure to disease because people use contaminated waters (intended for irrigation) for non-agricultural purposes. Large dams built as irrigation or energy projects have been irrefutably linked to increased water associated diseases in Africa (Roggeri, 1985) but there is a paucity of research on small dams (Ripert and Raccurt, 1987). This paper presents results of a rapid qualitative assessment of the health consequences of small concrete dams (height less than 3 meters, length 100-150 meters)in the Dogon Region of Mali, West Africa. The purpose of the study was 1) to document adverse health conditions related to the dams, 2) recommend remedial interventions, 3) develop environmental health assessment guidelines for proposed small dam irrigation development projects, and 4) assess other health risks related to water supply and sanitation.

The Dogon and Dams. Mali is one of the poorest countries in the world with a GNP per capita of $221. The population is approximately 9 million. About 300,000 live in roughly 400 villages in the region studied - the Dogon. The literacy rate is 17%. Health statistics are correspondingly stark. Life expectancy is 47 years and the Infant Mortality Rate is 151/1000. Approximately 85% of the total labor force is employed in agriculture and this sector accounts for 52% of the GNP. The construction of the first small concrete dam in Sangha, in the Dogon, in the late 1940's was an important landmark in the diffusion of gardening, the primary income producing activity in the region. To date 108 additional dams have been constructed by a variety of donors.

The Dogon is in the Bandiagara plateau in central Mali. The semi-arid area has two seasons; a dry season from October to May, and a rainy season from June to September. The mean annual rainfall from 1965-1991 is 467.0 mm. The terrain is rugged, rocky, hilly country with scattered tree cover, deep gorges, valleys, and large eroded sandstone outcrops. The infrequently flat rocky spaces are covered with very thin soils with little water retention capacity. These poor soils make up the largest part of the plateau's arable land. Onion gardening takes place near water sources because gardens are hand watered. Of all the resources within a village territory, water for irrigation is considered the most valuable because dry season market gardening is the only source of income.

Health Impacts of Dams. Dams and their impoundments are associated with negative health impacts primarily for two reasons. First, the dam structure and the impoundment may provide a suitable environment for the proliferation of disease transmitting hosts and vectors of parasitic diseases. Second, the provision of a reservoir in an otherwise arid setting, often leads to increased human contact with contaminated water. Drinking, cooking, bathing, clothes washing,

USAID, Washington, DC

swimming, and water collecting activities occurring with impounded water may result in transmission of disease. In order to investigate health impacts, this study used a classification of water associated diseases which breaks health problems into four categories: water-borne, water-washed, water contact, and water related after McJunkin (1982). Water-borne diseases are those in which the disease producing agent or microorganism enters the body as a passive component of drinking water. Water-washed diseases cover those illnesses where water availability and quantity rather than quality are the criteria for health. Water contact diseases are transmitted by human contact with pathogen infected water. Water-related diseases depend for transmission on animal vectors which live all or part of their lives in or near a water habitat, e.g. mosquitoes, flies. Representative and locally significant diseases within each category studied were:

- Water-Borne: Diarrheal disease and Dracunculiasis (Guinea Worm Disease)
- Water-Washed: Skin and Eye infections
- Water Contact: Schistosomiasis
- Water Related: Malaria and Onchocerciasis

MATERIALS AND METHODS

The study was conducted by a six person interdisciplinary team which included three Malians. Four weeks were spent in Mali during September, 1991. The team sub-disciplines were public health, tropical disease, anthropology, environmental engineering, water resources management, and construction engineering. Due to the absence of baseline health data in villages where dams had been built, for comparative purposes villages with and without dams were studied. Focus group discussions using a questionnaire developed by the team were conducted in each village. The questionnaire covered knowledge, attitudes and practices in 1) drinking water supply, use, storage and collection, 2) hygiene and 3) health with a focus on water associated health conditions. Men, women, and children were questioned, usually separately. Detailed diagnostic, epidemiological or environmental measurements were not conducted as these were beyond the time frame and scope of the study. At the village level all interviews were conducted in Dogon . Field observations were made of 1) structures including the dams, reservoirs, and sanitation facilities, 2) water contact activities, 3) water sources, 4) water collection, storage and filtering practices, and 5) sanitation facilities. The team visited 13 villages with populations ranging from 100-1,000 during a 12 day field period. Additional information was gathered through interviews held in the capital, Bamako, and in the field with government agencies in Bandiagara, international donors and non-governmental organizations.

RESULTS AND DISCUSSION

Diarrheal diseases. Villagers considered diarrheal diseases the most lethal of all illnesses. Diarrhea diseases are most common during the rainy season and affect people of all ages. These diseases are particularly common among children under 5 and are a typical cause of death of infants. In a sample of 155 children, diarrheal disease for the period two weeks prior to the study ranged from 8-35% in the villages. One village estimated that diarrhea kills one of every two children. Many villagers were unsure of the cause of diarrheal disease although some association with poor drinking water or bad food was mentioned. This lack of health knowledge results in practices that can increase infants' risk of diarrheal disease. For instance, many Dogon mothers supplement breast milk for nursing infants with drinking water. Home remedies are used for treatment. Surprisingly, only one village was aware of the most commonly accepted and promoted form of treatment, Oral Rehydration Treatment (ORT).

Guinea Worm Disease. Guinea worm is common throughout the Dogon. Due to a national guinea worm eradication effort which includes the participation of a number of Peace Corps volunteers, most villages knew of the connection between Guinea Worm and the drinking water supply. In villages with no improved drinking water supply, health education programs had attempted to teach safe water filtering techniques. However, observation revealed that these were not practiced correctly leading villagers to mistakenly believe they were drinking safe water. Villages with an improved drinking water supply, i.e. hand pump or borehole-cistern well, noted the eradication of Guinea Worm which accompanied the provision to the village (and use) of the improved water supply source.

Yaws, Eye and Skin Infections. Yaws, which is prevented by good personal hygiene, is endemic. As compared to villages with dams, in villages without dams the children appeared more dirty, had more eye and skin problems. Yet, skin infections were common in all villages particularly among children. Cases of trachoma and conjunctivitis were a common complaint. Villages without dams had dirtier children with runny eyes and other skin problems. When children swim and bathe in impoundments, and people wash clothes with more frequency because of the proximity of the dam, water washed diseases seemed to be reduced.

Schistosomiasis. Virtually all schistosomiasis in the Dogon is Schistosoma haematobium which is characterized by blood in the urine - an easily recognizable symptom to villagers. Transmission occurs when an individual comes into contact with infected surface waters. Schistosomiasis was present in all communities. Because schistosomiasis is so widespread, has existed as far back as the elders can remember, and the evident symptom (blood in the urine) eventually disappears, many Dogon do not consider schistosomiasis to be a disease and rarely seek treatment for it. Blood in the urine is thought to be sent by God or is considered a necessary rite of passage for children. If dams result in increased habitat for the host vector, snails, and water contact activities increase as a result of the presence of an impoundment, then dams could be the cause of an increase in schistosomiasis. Therefore, the team looked for habitat suitable for snails, the host for the disease causing vector of schistosomiasis, and water contact behavior. Aquatic vegetation, which serves as a habitat for snails, was found in most reservoirs. Where it was not present, this was due to inappropriate environmental conditions, not harvesting. Since control measures for schistosomiasis include removal of the aquatic vegetation, the team was interested in perceived benefits of the vegetation. Some villagers thought it reduced evaporation; other mentioned that it was good for fish; it is used for animal feed; and some people eat the fruit of the lily pad. Since no negative effects are associated with the vegetation, education appears necessary to convince villagers of the importance of removing aquatic vegetation from the impoundments.

Numerous water contact behaviors which place villagers at increased risk of schistosomiasis transmission were reported and/or observed by the team. Irrigation techniques place workers at high risk. Workers wade knee deep into the reservoir and fill a vessel (calabash) by submerging their hands and arms into the water. This procedure is repeated many times daily. Crops are hand watered with water from the calabash. Measures have been proposed in the Dogon to protect workers such as the use of hand pumps to deliver the water to the fields. These have been unsuccessful. Recreational and domestic water contact behaviors were also examined. Although most villages associated swimming in the reservoir with "itchy" skin and rashes, only in two villages were children forbidden to swim in the dam. Washing bodies and clothes was also observed by the team.

Malaria. Malaria, a disease transmitted by mosquitoes, is endemic in the region. While impoundment and water use create additional potential breeding sites for disease transmitting mosquitoes, malaria is endemic both in villages with and without dams. There is no active control program. Many Dogon complained for fever, the main symptom associated with malaria. Very few villagers related the disease to mosquito bites, another indication of the inadequate health education in the region. In a sample of 107 children,38% (41) had malaria-related fevers at some point during the previous rainy season. Tractional remedies are most commonly used. However, house construction, sleeping behavior, and mosquito biting patterns suggest that this might be a suitable region for the use of bed nets, a malaria control strategy.

Onchocerciasis. Onchocerciasis is transmitted by black flies which breed in rivers and streams. Dam spillways are particularly suitable breeding sites, hence the relationship with dams. Mali was included in the original zone covered by the World Health Organization (WHO) Onchocerciasis Control Program. After 15 years this program has proven very effective and a generation has grown up without this disease and the associated blindness.

Water Supply and Sanitation Conditions. Since the drinking water supplies used by a village, sanitation practices, and hygiene behavior all impact upon the diseases examined in this study, these areas were also examined. The sources of drinking water were found to vary throughout the year and were related to the seasonal rain patterns. In the four month rainy season, running streams were commonly used. As the dry season began, these waters were depleted as were shallow wells and puddles - additional drinking and domestic water supply sources. Later in the season, with wells and puddles depleted, shallow holes are dug in the dry river bed and water for drinking collected in this manner. Many villages in the Dogon, even those without dams, have a protected water supply source provided by various donor organizations. Only one village in this study had no protected water supply, nor did it have a dam. Safe drinking water supplies include improved wells and boreholes equipped with hand pumps as well as borehole-cistern wells. All villages with dams had an improved drinking water supply source which had been provided usually some time after the dam had been built. For several years, the provision of a safe drinking water supply for the village has been required of small dam development projects. One question to be answered in the study was whether villagers drink the water impounded by the dam. All villagers clearly knew to say they did not drink impounded water. They had been instructed not to. However, further probing and discussion of the importance of honest answers, revealed that all but one village studied with a dam, drank the impounded water at least occasionally. The village that did not was the only village studied which had a school and strong health education program within the village. This is an example of the impact of education on health conditions. Despite warnings and the presence of alternative, usually safe drinking water sources, the villagers choose to drink the impounded water because of convenience and taste. When the pump is a 20-25 minutes walk from the village compound and the dam is 5 minutes, villages drink from the dam. Another issue of convenience involves the scarcity of rubber well bags used to draw water from the well. This scarcity requires some families to wait their turn at the well. Compounding the convenience issue, is the question of taste."Sweet" tasting ponds are often preferred drinking water sources over water from the hand pumps which often has an iron taste. This is due to corrosion of the pipes, a problem recognized and currently under investigation by the World Bank. No economical solution has yet been found to this technical problem.

A safe drinking water supply is not sufficient to realize health benefits. Proper use and maintenance of the protected water supply are essential. Several observations suggest that unsafe practices are in use in many Dogon villages. No well covers are used. Wells installed with covers have had them removed by the villagers who find lifting heavy covers a nuisance. There is no safe method of retrieving water from the wells. A winch and pulley system would help. Here, where villagers wade into a river, stream or pond to gather drinking water, Guinea Worm disease is prevalent. Water filtration was used in one of these villages but the method used was incorrect.

Most Dogon compounds contain thatched or walled enclosures used for urination and bathing. When far from the village, Dogon urinate wherever it is convenient or private.Defecation practices vary amongst villages. For fear the feces ill be used against them in harmful "medicines" many Dogon attempt to be as inconspicuous as possible when defecating. Most villages have no latrines, so residents defecate "in the bush" or in the area surrounding the village sometimes within 10 meters of the house. Usually however, defecation takes place at a distance of some 50 meters from the village with the exception of children, the elderly and the ill. Little children defecate in the house until about age 5. The location of "bush" defecation sites varies. The team observed sites both at higher and lower elevations from the village. Some of these sites were located near rainwater pools and other seasonal supplies of drinking and bathing water. The team found human excrement in close proximity to the dams in several villages. These conditions provide favorable conditions for many of the illnesses studied. Pit latrines were rare and associated with public services such as schools, rest houses, and schools. The few cases of privately owned latrines belong to village chiefs, merchants, mid-wives, government functionaries or families with members who had migrated to urban areas. Human excrement was often found by team while on inspection of the dams in close proximity and certainly would be washed into the reservoir during the rainy season. Most villagers were very interested in building latrines with the main advantages being privacy, convenience, easy access and social status. The main obstacles were cost, lack of knowledge on construction, and a national latrine construction program hampered by lack of funds, transport, and staff.

Villagers perceive clear economic benefits to dams. In addition, they claim health has improved since the dams were constructed. It is not clear if this perception is due to the general association of dams with well-being, an actual improvement of nutrition, or better health related to water washed diseases.

CONCLUSIONS AND RECOMMENDATIONS

The study concluded that dams are a source of increased prevalence and intensity of schistosomiasis but because they are not a primary source of drinking water, they do not present other significant health risks. On the positive side, dams may result in slightly reduced water-washed diseases. Clear linkages between other health problems and the presence of dams were difficult to demonstrate given the complexity of disease transmission and of human behavior. A relationship between unsafe drinking water and disease was evident particularly in the case of Guinea Worm disease. Lack of basic health care, lack of education, and poverty all exacerbated unsanitary living conditions and hence risks to health from water associated disease in all villages studied. It was concluded that there are other pressing health issues which should be addressed particularly diarrheal disease control.

The team attempted to make simple, implementable recommendations to the GRM, non-governmental organizations, USAID, Peace Corps, Africare and other bilateral donors, and multilateral donors. Recommendations are detailed elsewhere (USAID, 1992) and include:

- continue the national schistosomiasis treatment program and expand to all villages in the Dogon
- improve health education
- ensure provision of a safe drinking water supply in all small dam projects and remove unsafe water sources
- involve the community in all aspects of dam, water supply and sanitation
- consider alternative irrigation approaches and other measures to minimize water contact (Brinkman, 1986)
- construct dams with mechanisms which allow for regulation of the water retention, e.g. sluice gates (Pike, 1987)
- consider alternative dam designs including ones to reduce evaporative losses
- explore groundwater resources
- Guinea worm activities expanded possibly to filter production within country
- Direct health and hygiene education programs to women
- explore malaria control practices, e.g. wi
- pilot latrine construction program implemented
- target the Dogon for Child Survival programs, particularly ORT

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EDUCATION, TRAINING, AND RESEARCH FOR EFFECTIVE MANAGEMENT OF COASTAL RESOURCES OF THE YUCATÁN - MÉXICO

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Abstract: Education, training, and research are key elements for coastal zone management of the Yucatán Peninsula of México. Empirical studies of biological and human diversity are critically important to sustainable development planning initiatives in the region. Equally as important for the implementation of planning initiatives and policy decisions related to environmental protection and economic development are the education and training activities being undertaken in the peninsula. The Centro de Investigación y de Estudios Avanzados, Unidad Mérida (CINVESTAV), along with PRONATURA, Península de Yucatán, AC (PRONATURA/Y), both Mexican organizations, have agreed to collaborate with Colorado State University (CSU) and other research groups and various governmental and non-governmental agencies to foster a program of resource conservation in the coastal zone of the Yucatán Peninsula. Results are expected to include expanded environmental protection for the State of Yucatán coastal wetlands and the extension of an innovative 200,000 hectare "biodiversity bank" proposed for the northeastern part of the peninsula encompassing the wetlands in the adjacent state of Quintana Roo. The cooperative joint efforts include education, training, and research in the application of scientific and technical information regarding resource conservation, natural hazard mitigation, and ecotourism development within overall coastal zone management of natural and human ecology of the area.

BACKGROUND

Historically, the Yucatán region prospered greatly from the sisal (henequén) industry until synthetic fibers captured the world market in the 1950's and 1960's. The Yucatán also was effected by the economic recession following the drop of world crude oil prices in the early 1980's. Because of low rainfall and vulnerable soil conditions, there are few options for alternative crops and a limited potential for the expansion of cattle ranching.

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At the coast, expansion of fisheries is limited by the capacity of the natural resource. Expansion of other coastal industry is limited by basic infrastructure, international markets, and location. An alternative for economic diversification in coastal region is tourism, especially nature tourism known as ecotourism.

The beaches of the State of Yucatán face the shallow, turbid Gulf of México, while the neighboring state of Quintana Roo borders on the clear, blue waters of the Caribbean. Cancún, in the State of Quintana Roo, is one of the fastest growing cities in México. It is currently visited by several million tourists per year, and the resident population is projected to reach one million by 1994. The State of Yucatán also is experiencing growth in coastal recreation housing and resort development. The development pressure in the State of Yucatán has caused concern and promoted action regarding planning and management of new development that is compatible with the biological, cultural, and human resources of the coastal zone all of which are the basis for expanded ecotourism and sustained economic development.

Much of the interest is focused on resource conservation of coastal ecosystems, such as the unique lagoon/wetland complex that extends from Celestún, near Campeche, eastward across the Yucatán coast and south along the coast of Quintana Roo (Figure 1). This region contains a complex system of lagoons and wetlands along with extensive mangrove forests. The mangrove produces far more charcoal, poles, and firewood per hectare than inland forest. In addition, the mangrove forest provides a barrier against coastal erosion (Ackerman et al. 1991). Along with other naturally occurring mitigating elements such as reefs, dunes, and marshes, the mangrove forests reduce the impact of natural hazards on human populations and economic and social infrastructure (Bender 1991). The mangroves also provide the cornerstone of biological diversity for the peninsular coast, therefore, they also are areas for potential ecotourism development (Whelen 1991).

The northern coastal portion of the Yucatán is home to 20,000 flamingos, plentiful waterfowl species, and resident and migratory shorebirds. The region supports major shellfish and fish resources, serving as nurseries for species upon which local fishermen also depend. The area provides habitat for numerous endangered and/or threatened species and is of unexcelled natural beauty. It has been identified by the Nature Conservancy as one of the ten important places to be preserved in the hemisphere.

México has designated Río Lagartos a biosphere reserve, and also its charter site under a world treaty for the protection of wetlands of international importance, popularly know as the "Ramsar Convention." Río Celestún is a major national wildlife refuge. Other state parks, such as El Palmar and Dzilám Bravo, complete the coastal ecosystem along the northern coast of the Yucatán Peninsula. However, this is only part of a large wetlands habitat that extends from the Laguna de

Términos in Campeche, through the state of Yucatán eastward into Quintana Roo. A major component of the current project described in this paper is to conserve the entire ecosystem from Celestún to Reserva Norte.

The productivity and beauty of these resources are now jeopardized by the uncontrolled, coastal real estate development, industrial expansion (e.g. salt mining in Río Lagartos), and the build-up of tourist facilities. This is particularly critical on the Caribbean side where Cancún Lagoon and the coastal zone south to Tulúm are in danger of extreme pollution from overdevelopment (Daltabuit and Pi-Sunyer 1991). Along the western side, continued loss of habitat has significant negative impact on the carrying capacity of the ecosystems especially for waterfowl, indigenous wildlife, migratory and resident species of songbirds, and marine nursery grounds. The sustained use of these areas by people, and the economic viability of the region, is dependent upon the preservation and sustainable use management of the biological resource (Heyman 1991).

Currently, the key missing element is the scientific and technological base of information upon which informed consensus-building, decision-making, and policy implementation can proceed. The factual base of information about biological diversity, human ecology, and other elements is necessary for the design of an environmental future for the peninsula and the people who live there. The project described in this paper would contribute to the strategy for sustainable use of the resources of the Yucatán.

DESCRIPTION, PURPOSE, AND GOALS

Cooperative Project Objectives and Strategy

The major objective of the cooperative project described in this paper is to organize a collaborative education, training, and research venture between CINVESTAV/Mérida, Colorado State Universtiy (CSU), the University of Colorado at Boulder (UC/B), PRONATURA/Yucatán, and other Mexican and United States institutions and organizations. The central purpose is to build an authoritative data base to enhance consensus-building, decision-making and policy implementation of short-term and long-term strategies for the sustained use of the resources of the region. The project will use a geographic information system, such as PC-based ARC/INFO, to aid in the management of the biological and human system data and to aid in the planning process for environmental protection and economic development.

By-products of these major goals include continuous training and educational activities coupled to main research and development activities. For example, identification of pollution sources is expected to contribute to policy incentives and

and/or regulatory guidelines for mitigation. The outcome is expected to include enhanced fisheries production, thereby contributing to sustained use of the region by local peoples. In addition, reduction of pollution will contribute to more robust ecosystems capable of sustaining more resilient populations. If the biodiversity of the area is preserved, then the potential advantages of economic development options such as ecotourism are enhanced. In addition to the biological advantages of ecotourism, the economic and social benefits include a way to pay for the protection of areas of natural and cultural significance and for the management of parks and protected areas (Bender 1991, Heyman 1991). The small scale, less capital intensive, decentralized ecotourism also includes involvement of local people and a more directly accrued economic benefits to them (Oliver-Smith et al. 1989).

Collaborative Process and Institutions

An informal network has existed for some years, involving scientists and technical experts from the Yucatán and the United States in ecology, botany, archaeology, geography, marine biology, natural resources management, architecture, sociology and other fields from institutions including those represented by each of the authors of this paper. People from cooperating institutions and organizations in both countries are committed to the work on the pure and applied aspects of the research on the Yucatán and simultaneously on present and future cooperative opportunities for education and training of students, professionals, and others including the local peoples in the areas of natural resource conservation and management.

In collaboration, these people and institutions have been assisting national conservation organizations to survey, plan, and establish protected natural areas in the Yucatán Peninsula. This collaboration has contributed to upgrading of ecological management in several habitats. The training of local people as resource managers and ecotourism guides has been accomplished. Of equal importance, the collaborators have gained experience and confidence in working together and have learned from each other.

Private industry also has been positively involved. Industría Salinera de Yucatán, SA (ISYSA), which operates a major salt works inside Río Lagartos, has engaged in productive dialog to save the flamingo flock. The international mining consortium, CALICA, owner of a major strip mine near Cozumel, is providing funds to assist PRONATURA in conservation projects and is working with CINVESTAV through funding of environmental impact assessments and monitoring activities.

An effective dialogue between citizens, government, and other entities regarding the development of the environmental program also is being achieved. The success of these public/private cooperative efforts have been greatly enhanced by the environmental eduction and training undertaken in the peninsula.

Strategy and Goals of the Project

A major goal of the joint cooperative project, and an important key to the success of the long range strategy of sustainable development, is further cooperative research to support the ongoing education, training, and outreach activities. The education, training and outreach contribute to consensus building, decision-making, and policy implementation regarding the protection and conservation of the resources of the Yucatán and the sustained use and management of the resources. The goal of integrating resource conservation with the economic and social needs of the Yucatán community has been enhanced by the integration of the scientific and technical aspects along with the social, economic, and cultural realities of the region. The goal of the project is to provide the scientific foundation for biologically and socially appropriate conservation and management of the natural and human resources the Yucatán coastal region through a linked network of parks and protected areas along with already developed areas under high use such as the port city of Progreso.

The interrelated issues of natural resource conservation, natural hazard mitigation, and economic development options such as ecotourism are important elements for strategies for sustained use of the region. If biodiversity is preserved in the Yucatán Peninsula, traditional resource use such as fisheries and indigenous agriculture will be enhanced and new sectors of economic development, such as ecotourism, are more likely to be successful.

In addition, other benefits of protecting and conserving ecosystems include natural hazard mitigation which translates to reduction of losses of life and property. The naturally occurring mitigation elements of ecosystems such as mangrove forests, dunes, marshes, and reefs are not only biologically significant, but can offer additional protection from natural hazards that range from severe events like hurricanes to ongoing natural hazards like coastal erosion. If these areas are incorporated into parks and protected areas they also can be managed by local people (e.g. through ecotourism) and are of economic benefit to them. Using ecotourism as an economic development option, the areas may be less subjected to human disturbance with has been shown to contribute to the increased negative effects of natural hazards (Hewitt 1983). For example, when Hurricane Gilbert hit the Yucatán Peninsula in September of 1988, the barrier island of Río Lagartos was cut in 21 places (NAS 1988). Some of the destruction was attributable to the magnitude of the hurricane (Perry 1989), but human disturbance of the ecosystems systems also contributed to the short-term and long-term losses in the area. Currently, repercussions are still evident on the ecosystems, the industries in the area, and the local economy (Clark 1991). Appropriate management of the natural resources can contribute to decreased losses to the ecosystems and humans and enhanced economic well-being.

Knowledge about interrelated environmental and societal issues is key to the concept of sustainable development in this region as elsewhere. The scientific research, education, and training that is underway in the Yucatán Peninsula, and the new joint initiatives are important components of the strategy for sustainable use of the region.

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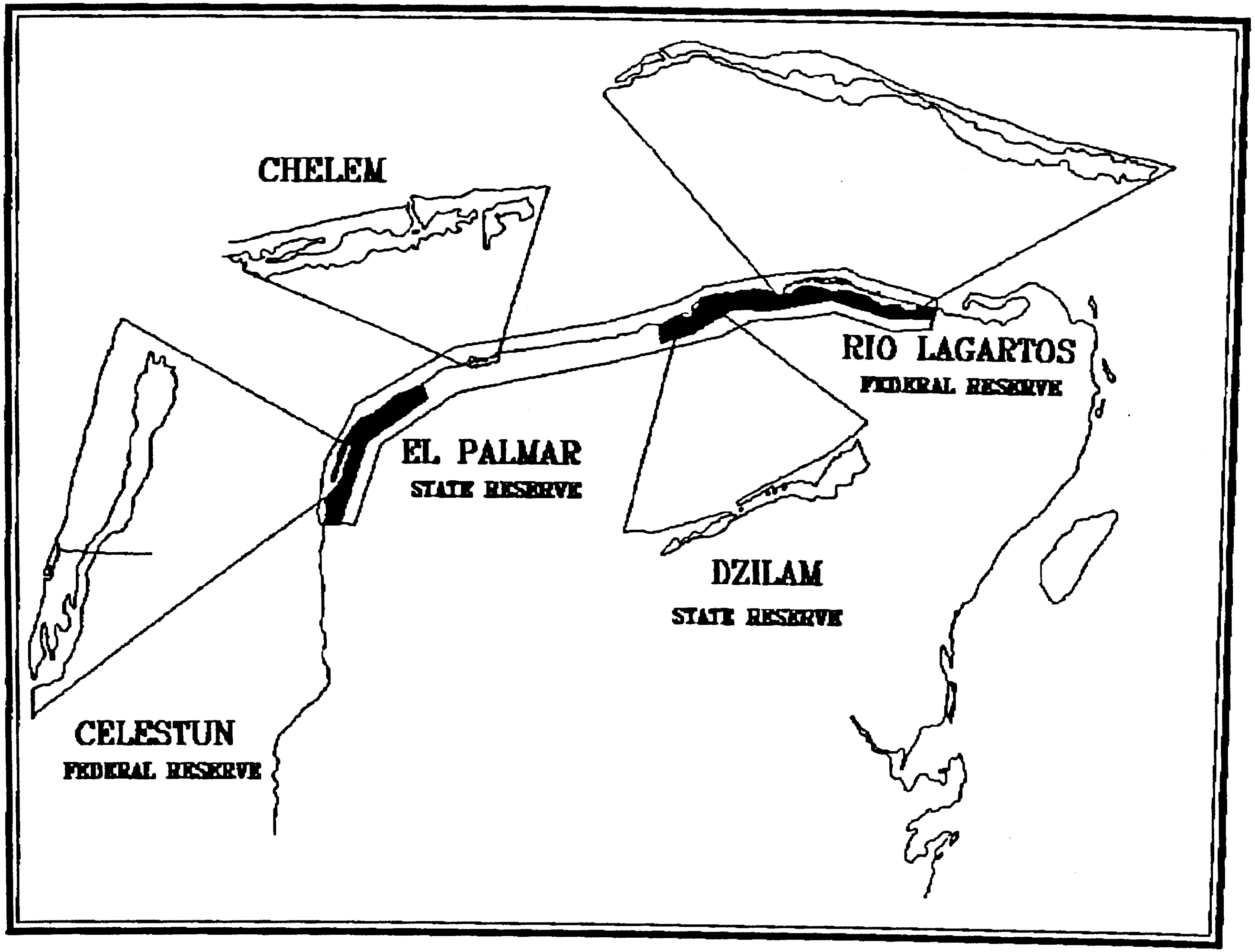

Proposed Study Area

Shading depicts current natural protected areas

COMPUTER ASSISTED WATER RESOURCES EDUCATION AND TRAINING

Azad Mohammadi[1]

ABSTRACT

For nearly three decades, the field of water resources has been subjected to a great deal of experience associated with developing and using analytical and computer-based models. These models have primarily been developed as tools to educate and train water resources managers in facilitating the water resources decision making process. The success or failure of water resources models have been affected by numerous factors among which, the process of model development and use are more pronounced. This paper describes the importance of these processes and factors that can influence successful water resources model development and application.

BRIDGING THE GAP BETWEEN MODEL DEVELOPMENT AND USE

Most of the constraints to successful model implementation can greatly be reduced by recognizing the most critical factors that could potentially be influential during model development and use. Such factors can range from intelligent problem formulation at the model development stage, to continuous updating of the model at the implementation stage. These and other components should be well recognized and dynamically linked together by means of strong interface between model developer and user. Figure 1 is a diagrammatic representation of the required relationships and linkage at the model development and implementation stages.

Problem Formulation - The process of problem formulation or definition should involve determining model specifications, objectives, constraints, scope of the model, as well as the decision variables that the

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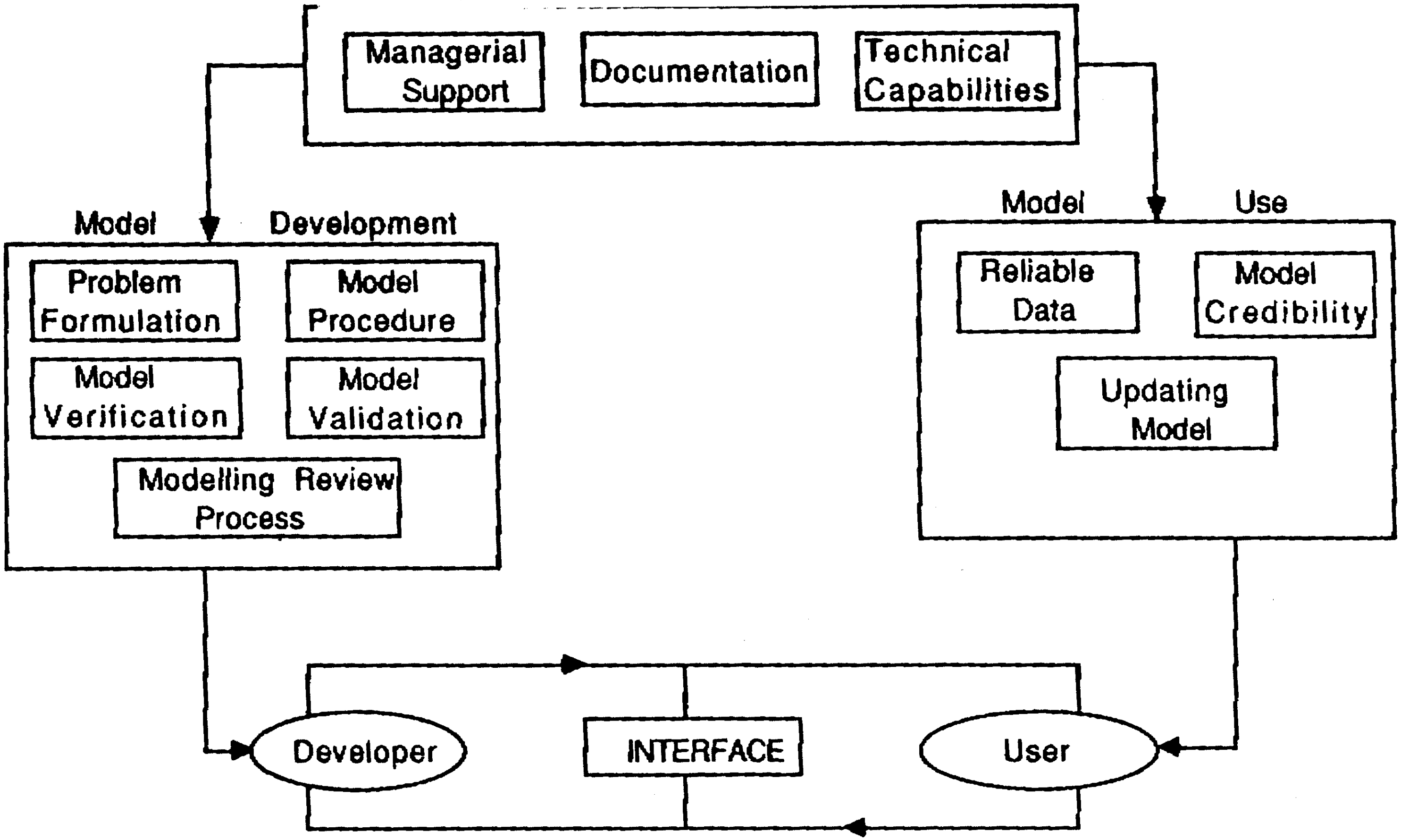

Figure 1. Relationships Among Systems Components of Model Development and Use

decision maker can control. It is essential that the modeler and the end user should agree on definition of the problem to be modeled.

The next step is to decide which type of input and output display is more appropriate. The interface should embrace a friendly problem-solving environment which will allow the user to directly control the solution process and the user's ability to introduce subjective information as demanded by the problem solution process. Such flexibility should be supported by sufficient feedback so that the user is dynamically and fully aware of the state of solution generation process.

<u>Modelling Process</u> - Efficient modelling procedures should involve step-by-step model design which will allow flexibility in revision as additional information becomes available. For example, a review of data often causes reformulation of the problem. This is true in the case where some data are not obtainable. Actual runs of the model almost always suggest new alternatives, and therefore, a return to an alternative definition. This makes modelling an art rather than a science.

<u>Model Verification</u> - This step involves determining whether the statement of the problem (i.e., the computer program) exemplifies the desired model under expected conditions. This includes comparison of the model results against the historical record. The computer program must be thoroughly tested to ensure that it does represent the desired model. Obtaining the correct results is a prerequisite to model validation.

<u>Model Validation</u> - The validation step seeks to establish how close the model reflects the reality. The number of ways in which incorrect model results can be generated can be immense. It is logical to articulate that all computer models are capable of producing faulty results. Unfortunately, there are no widely acceptable standards for the testing and validation of computer models. However, minimum requirements or standards should be established for accepting model results.

<u>Modelling Review Process</u> - Model review process is a way of determining both the validity of the model to

represent the reality as well as its usability in support of decision making. This is essential for governmental in-house modelling activities. In an in-house environment, the primary obstacle to model review is the need for job security.

Reliable Data - The necessary integration and coordination of model usage is achieved largely through the data base. Presence of a reliable source of data is an integral part of successful model implementation. This is more critical in real-time operation of water resources systems where decisions are made in a short time frame. Most of real time operation models have suffered from lack of sufficient data to support the model use.

Model Credibility - For a model to be credible, a framework is needed which would define what constitutes a reliable and credible model. Within such a framework, there will be elements that directly or indirectly influence the degree of usability and, therefore, credibility of the model. By definition, credibility of a model is judged by the user. Therefore, model credibility could be established over a period of time in an environment where model development and use is exercised.

Updating Model - The initial definition of the model and its parameters is often based on data analysis. Subsequent modification and revision of the model requires reexamination of the data, particularly to include more recent data which may signal a change in the basic relationships between the variables in the model. Models should be updated periodically and tested with new sets of data.

Documentation - Documentation should be an integral part of model development and use. Documentation serves as an interface which would facilitate the communication between the various people who must be involved in the modelling activities. Such means of communication must be established at the model development stage and continue throughout the process of model use.

Technical Capabilities - Building a model demands a rigorous understanding and definition of the problem to be solved. Often this is a highly technical task. This effort can be better facilitated by the presence of both modeler and user in the same agency.

Managerial Support - A significant factor of successful model application is the managerial support at all stages of modelling activities including development and implementation. Such support can range from encouraging model use, to providing funding and manpower. Any modelling exercise should involve support from all levels of decision making and the decision makers should allocate funds for the initial model development effort on the basis of their judgement and faith in the lead analyst.

CONCLUSIONS

Modelling technology has been and will continue to be influential in water resources training and education to effectively and efficiently manage water resources systems. However, successful model development application requires understanding of the most critical factors that can affect the modelling exercise. Presence of an efficient interface that can dynamically link model developer and user is also essential in using models to support decision making.

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SESSION X PLENARY

MINORITY EDUCATION IN WATER RESOURCES AND ENVIRONMENT

MINORITY EDUCATION AND INVOLVEMENT IN WATER RESOURCES

by

Victor I. Okereke[1], Ph.D., P.E.

ABSTRACT: Central State University has the nations only full-fledged degree program in water resources management at the undergraduate level. The program as well as the Center which runs it came into being a few years ago. Both were founded on the assumption that water resources management can and should be taught at the undergraduate level as well as at the graduate level; that the best solutions to any water resources problems must address the technical, as well as the political, social, cultural and economic aspects of the problem. The International Center for Water Resources Management (ICWRM) at Central State University has been very successful in blending all these aspects of water resources problems into an acclaimed undergraduate program.

In this paper, the author describes this unique program, its successes as well as its pioneering efforts in educating minorities in the water resources field. Besides, the author describes the efforts of the ICWRM to engage undergraduate students in significant research in water resources. It is hoped that the success of this Center at Central State University would serve as a model that could be implemented in other parts of the country.

INTRODUCTION

In 1985, the Ohio Legislature authorized Central State University, a state-assisted public university in Wilberforce, Ohio to start an international center for water resources management. The goal was to develop a center of excellence in water resources that would approach the solution of water resources problems from several angles. These include engineering, economics, public policy, law, and the local culture. It was

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planned that the Center would develop and nurture the first-in-the-nation baccalaureate degree program in water resources as well as develop a research program with a broad range of projects: locally, nationally and internationally. Furthermore, it was to develop a strong educational program with the bachelor's degree program as its core, supplemented by a wide range of short term training programs such as conferences, short courses and non-traditional public education.

As the only state-assisted historically black university in Ohio, Central State University has the historical responsibility to provide college education to blacks in the region. Therefore, the above objectives were to be accomplished in that context. The Center was therefore expected to focus attention on minority education and access to careers in the water resources field.

EARLY DEVELOPMENT

From the very beginning, the founding fathers of ICWRM were determined not to develop it as just another center on Central State University's campus. Instead, it was to be unique, flexible and offer programs that are not only current, but also responsive to the needs of the constituencies it was intended to serve. With this in mind, the university sought a planning grant from the Ohio legislature. So in 1985, the General Assembly approved a grant of $400,000 to enable CSU plan for and establish the proposed water resources center. The money was to be used over a two-year period.

The planning process as well as the implementation were Herculean tasks. First CSU had virtually no experience in establishing and managing a center with such a wide range of interests and complexity. While there were center of excellence already in existence on campus. each had a somewhat narrow focus. Secondly, water resources education in the United States has historically developed as graduate programs. Until ICWRM was founded, no other university in the United States offered a undergraduate degree in water resources. In fact as far as this author knows, the only one of its kind in the country.

So, CSU had the added problem of what to do with a traditionally graduate degree program in a traditionally undergraduate university. A way out was to simply start a traditional water resources program at the master's degree level and use that as a basis for its proposed graduate school. This option was considered and rejected as unlikely to succeed partly because everything about water resources at CSU was to be built from the ground up. At the time, the University had no one on its faculty with expertise in that area.

Another alterative was to chart a new course, take a bold step and offer the program at the undergraduate level. This was considered and accepted partly out of necessity and partly because it appeared more logical than the other alternative. So, with the planning grant from the state, CSU hired the best water resources professionals it could find to develop the Center and its unique educational programs.

A whole curriculum had to be developed including all the courses that would lead to the new degree program. These courses as well as the curriculum must be tailored to undergraduate education. Since there was nothing on the market at the time, the task was formidable. Besides, most existing water resources programs in the country approached the subject from one of two sides: "hard" sciences (engineering, geology, etc) or "soft" sciences (political science, economics, etc). ICWRM was bent on covering all facets of the subject. The program was designed to ensure that no student would graduate from it without significant exposure to the "hard" and "soft" aspects of this fascinating subject.

So with the blessing of the Ohio General Assembly, ICWRM officially came into being in 1985. But it was not until 1987 that the Center enrolled its first set of students. Actually there were two students to be exact. Both transferred into the new program from other departments.

EDUCATIONAL PROGRAMS

Degree Program: As stated above CSU has the nation's first and only baccalaureate degree-awarding program in water resources. Students in the program may take courses in groundwater, hydrology, hydraulics and fluid mechanics, water chemistry, water treatment plant design, wastewater systems design, soil and water pollution, water policy, world water resources, economics of water resources planning, water law and so on. Naturally the student is required to take additional courses from mathematics, computer science, biology, chemistry, history, sociology, etc, to complement the core courses. Besides, an internship program of full time work in the field is required for graduation.

Non-Degree Programs: As part of its overall educational strategy, ICWRM offers a full range of short term (one year or less) non-degree training programs. These include short courses, seminars, conferences and individually-tailored training programs. Each of these is designed to meet the needs of students as well as practicing water professionals here and around the world. Most of the Centers initiatives in this area of non-degree programs have been very successful and attract participants from several foreign countries.

A very pioneering effort in short-term training is the Center's provision of individually-tailored training programs. These are training opportunities designed to satisfy the needs of a specific individual. The areas covered run the gamut of topis in water resources and are as individualized as the people who request for them. For instance, at the request of the United States Agency for International Development (AID), ICWRM provided a six-month training to a Pakistani engineer in computer applications in irrigation management. In another occasion the Center did the same for a senior-level Nigerian engineer at the request of the World Bank. In the later case, the interest was in earthen dams, a fairly narrow area of water resources engineering.

In addition to providing needed financial resources to the Center, these short-term training program have helped spread the word about the wonderful educational opportunities that are available at ICWRM. It has also helped establish the Center's reputation as a leader in international education in the growing area of water resources engineering and management. Hence, in just five short years, it has achieved one of its goals of becoming a center of excellence in water resources where people from around the world can come to see solutions to their water resources problems.

RESEARCH AND COLLABORATIVE PROGRAMS

Even though it is part of a university that has a small but growing graduate degree program, ICWRM has engaged in significant research since it came into being. The faculty has been successful in attracting funding for research in areas as diverse as water quality, droughts, hazardous wastes, irrigation management and hydrology, and even science education. And the locations of the research efforts are as far flung as the subjects being investigated. It has research projects that are conducted entirely on the university campus, while another is located about 150 miles from campus in the rural Appalachian region of Ohio. Still others are in such far away places as Senegal, Ghana and Egypt.

As a relatively small center, ICWRM does not have the resources to go it alone in many cases. This is especially true where the research site is far away from the university campus. Hence, it has developed and nurtured mutually beneficial collaborative relationships with several universities, agencies and even nations. Some of these relationships have a purely research focus, while others were designed to facilitate the transfer of technology. Still others are intended for student placement, while some are multifaceted.

Right now, ICWRM has active collaborative relationships with the host institution for this conference, Colorado State University, and with Cleveland State University, Ohio State University, Clark-Atlanta University, University of Cairo (Egypt), University of Science and Technology, Kumasi (Ghana), Assuiti University (Egypt), University of the District of Columbia, Northeast Ohio Regional Sewer District, and even national governments such as the Republic of Togo, as well as several others. These relationships have been extremely beneficial to the Center and to Central State University, as well as to the collaborating universities and agencies. They have had a synergistic effect on all parties involved. Naturally, ICWRM is committed to continuing these beneficial relationships as well as developing others.

MINORITY EDUCATION IN WATER RESOURCES

As a Center that is located in a historically black university, ICWRM is committed to providing quality water resources education to all, especially minorities. In fact, many of its programs are designed to support quality undergraduate education for minorities. Examples: (i) Undergraduate Student Research. Virtually every research project undertaken by the Center includes active student participation. So, undergraduate students work on projects as research assistants. The result of this is not only better education of students, but an increased interest in graduate study and research careers on the part of students in the program. So far 55% of all graduates of the program have gone on to graduate school. Virtually all of them were offered competitive research assistanceships based on their work at Central State University. (ii) Mentoring and Advising. The mission statement of Central State University requires it to have an open admission policy and to provide quality college education to the poor and underprivileged. Therefore the university admits students with less than adequate preparation for college. Such students generally need more guidance than the average student in order to make it through college successfully. Consequently, one-on-one tutoring, mentoring and advising are key ingredients in the success of ICWRM. Class sizes are also kept small to ensure that the faculty have time to devote to individual students.

Nationally, the success rate of in-coming freshmen with inadequate preparation for college is generally low. Many drop out by the end of their first or second year. But that has not been the case at ICWRM despite the fact that its students come from the same population as similar programs around the country. In its first five years of operation, less than 5 percent of its students have dropped out. The reason for that level of success rests squarely on the individualized attention that each student gets from the faculty and staff. That is a model for success and it can be replicated in other parts of the country.

CONCLUSION

Minorities are grossly under represented in many scientific professions in the United States. In the water resources field, the problem is made worse by the fact that the field is relatively new and growing and by the fact that most formal water resources education begins at the graduate level. The programs described here is one attempt to attract and retain and train minorities in this important field. It has been so successful that other universities should not hesitate to replicate it in their own communities.

POSITION PAPER
MINORITY INSTITUTIONS COLLABORATION PROGRAM IN WATER RESOURCES AND ENVIRONMENTAL MANAGEMENT

By

Berhane M. Abraha[1], Ph.D., P. Eng.

ABSTRACT: There is a need to initiate a joint program on minority institutions collaboration as a primary goal to improve the status of water resources and environment management education, training and research in these institutions. This is with specific goals of developing mechanisms by which African Americans are attracted to graduate schools in the fields of water resources and environment and earn Ph.D. degrees. An additional goal is to extend the collaboration to selected African institutions.

This position paper presents the concept, evolution and development of the collaborative program. It describes the rationale for implementing the program and identifies the relevant program elements, general goals and objectives. And then points to the policy impacts expected by the program. It also describes what has been carried out so far to implement the program and the networking achieved between the collaborating Historically Black Colleges and Universities (HBCUs) and other Minority Institutions (MIs).

The ultimate purpose of the paper is only to be used as an agenda for the workshop and as a benchmark to stimulate further ideas and discussions in the development of the program. It invites and encourages the collaborating institutions that are represented in the Ford Foundation funded workshop to consider several alternative ideas and suggestions in order to further develop the program in water resources and environment education, training and research. Building the capacity of these institutions must be the ultimate goal of this program.

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1. PROBLEM STATEMENT

There is a need to initiate a joint program on minority institutions collaboration as a primary goal to improve the status of water resources and environmental management education, training and research in these institutions. This is with specific goals of developing mechanisms by which African-Americans are attracted to graduate schools in the fields of water resources and environment and earn Ph.D. degrees. An additional goal is to extend collaboration to selected African institutions in developing countries. Colorado State University would like to develop this kind of collaborative mechanism by which to improve the education programs and strengthen the minority institutions in the United States and institutions in developing countries(2).

Water resources and environmental problems are among the world's important issues. They include problems such as drought-induced water supply problems, water pollution, flood disasters and lack of safe drinking water and sanitation. And they relate directly to levels of economic achievement, environmental quality and public health. Issues like environmental equity are presently being raised in the United States as a new environmental initiative and awareness based on the experiences of environmental pollution within neglected communities.

Although the political systems of some nations are overwhelmed with water-related problems, education can contribute to the solution of the difficult socio-economic and environmental problems involved, and may be the program area with the greatest promise for helping in the long run. In the United States, it is recognized that investment in the education of American citizens and those of other nations will lead to benefits to water and environmental management. As the nation comes to grips with the immense problem of education its next generation of scientists, engineers and managers, it has come to recognize that providing enhanced opportunities for students from diverse sectors of the population will be a critical ingredient in the nation's ability to meet the challenges it will face. This is the primary issue faced by this program: educating Americans from minority backgrounds for careers in water and environmental management, with emphasis on collaboration with the Historically Black Colleges and Universities (HBCUs) and other Minority Institutions (MIs).

During the 1980s, the number of American citizens in graduate science and engineering programs has declined and the representation of the African-American students is low. Few are enrolled in the fields of water resources and environmental management; more are attracted to industry. In all fields there is a desperate need for Minority Ph.Ds (1). Colorado State University believes that this shortage can be improved by collaborating with selected established minority institutions in the United States thereby, increasing the enrollment and retention of minority students.

Wells and Howard (1989) remarkably depicted the desperate need for Minority Ph.Ds with statistics from the Commission on Professionals in Science and Technology (Table 1). The statistics indicated that this situation is not improving as we embark into the 90s.

Table 1. 1976-1988 Ph.D. Engineering graduates in the United States by Ethnicity

YEAR	TOTAL Ph.D.	TOTAL MINORITIES		BLACK		HISPANIC		INDIAN	
		No.	%	No.	%	No.	%	No.	%
1976	2,977	35	1.2	10	0.3	15	0.5	0	0.00
1977	2,814	39	1.4	16	0.6	22	0.8	1	0.04
1978	2,573	43	1.7	15	0.6	25	1.0	3	0.10
1979	2,815	41	1.5	19	0.7	22	0.8	0	0.00
1980	2,753	45	1.6	19	0.7	25	0.9	1	0.04
1981	2,841	39	1.4	16	0.6	20	0.7	3	0.10
1982	2,644	38	1.4	20	0.8	15	0.6	3	0.10
1983	3,023	60	2.0	19	0.6	41	1.4	0	0.00
1984	3,234	49	1.5	24	0.7	25	0.8	0	0.00
1985	3,383	70	2.0	32	0.9	34	1.0	4	0.10
1986	3,686	59	1.6	17	0.5	38	1.0	4	0.10
1987	4,175	59	1.4	18	0.4	35	0.8	6	0.10
1988	3,716	66	1.8	25	0.7	34	0.9	7	0.19

Source. Commission on Professionals in Science and Technology

Table is from Graduate Engineer Minorities Issue/April 1989, Wells and Adams (1989).

Colorado State University collaborates with many institutions and international bodies in programs related to water resources and environmental management. Colorado State wants to expand this collaboration and develop a support program with minority institutions to encourage African-Americans to pursue careers in water resources and environmental management.

In 1990, Colorado State has been cited for its excellence in water resource education. As a result of this recognition and with a new thrust to enhance diversity, a <u>Minority Institutions Collaboration and Support Program in Water Resources and Environmental Management</u> is being initiated. It is expected that this program will mushroom into a Consortium of HBCUs/MIs in Water Resources and Environmental Management.

2. PROGRAM DEVELOPMENT AND ELEMENTS

2.1. Program Development

During the exploratory stage of the program development, the program developers have conducted a questionnaire survey in order to collect relevant information and to explore program feasibility and interest in the program. A brief questionnaire was sent to 22 minority institutions (HBCUs and MIs) to solicit interest in the program and capture any valuable suggestions or strategies towards the main objectives of the program. Eight minority institutions expressed their interest in the collaborative program by completing the questionnaire or by sending letters of interest. Those institutions who showed interest have on-going activities and programs in water resources and environmental management. The results of the survey conducted is summarized in a separate report(3).

Currently Colorado State University is funded through the Ford Foundation to involve HBCUs/MIs in the Water Resources and Environmental Management research arena to conduct a technical conference and workshop. The "Water Resources and Environment: Education, Training and Research" Conference and workshop is to be held at Colorado State University during the period of July 13-17, 1992. Representatives from twelve HBCUs/MIs have been invited. Issues pertinent to minority participation in these areas of research and education will be discussed at this conference.

The initiation of the collaborative program will culminate at the Summer 1992 workshop funded by the Ford Foundation. It is expected that the workshop session will be a forum to facilitate the further development of the collaborative program between the institutions.

2.2 Planning for a Consortium

Recently, on May 26, 1992, Virginia State University and Colorado State University jointly organized a planning meeting in the area of Water Resources and Environmental Management. The purpose of this meeting was to provide a forum for discussion on the role of Historically Black Colleges and Universities (HBCUs) and other Minority Institutions (MIs) in this area of high priority and to assess the feasibility of the formulation of a new consortium to achieve the synergistic benefits of their collective resources.

Officials from several federal agencies and major corporations participated in the May 26th meeting, provided valuable input and expressed their strong support.

Among these agencies are the U.S. Department of Agriculture, Department of Defense, Department of the Interior, The Agency for International Development, The Environmental Protection Agency, Department of Energy, Oakridge National Laboratory, Natick RD&E Center, USATHAMA, The National Association for Equal Opportunity in Higher Education and the White House Initiative. The support for the establishment of the HBCUs/MIs Consortium was unanimous.

According to the recommendations of participants in the May 26th conference, funds may be available for planning purposes. During the planning phase, the capability study of the HBCUs/MIs will be conducted. The planning grant will defray the cost of developing the consortium management plan, bylaws, consortium initiation efforts and travel support for planning conferences and conducting capability and resources survey of HBCUs and MIs.

The workshop will discuss the planning and the establishment of the consortium of the HBCUs and MIs in Water Resources and Environmental Management. Issues like organization of the consortium, program development and support agencies effort can be subjects of discussion during the workshop.

2.3 Program Elements

Based on early plans and investigations, five program elements and general goals have been tentatively identified:

a) To develop research, continuing education and professional development opportunities for faculty of selected minority institutions in the fields of water resources, environmental sciences and engineering management. This would be done by providing release time for faculty members and exchange programs between faculty members of minority institutions and Colorado State University. This will encourage faculty renewal and development and increase participation and collaboration in research. Such a program can be extended to students for post-graduate and post-doctoral research.

b) To couple educational programs in water resources, environmental sciences and engineering at Colorado State and collaborating HBCUs institutions. One example that can be cited is to couple programs of water resources education at Colorado State and the International Center of Water Resources Management (ICWRM) at Central State University, Ohio to provide students with a post-graduate engineering degree. This can be performed by providing engineering-based course enrichment and electives at Colorado State University. Such a program might be expanded to other minority institutions.

c) To organize a Summer Workshop for faculty of minority institutions. This will facilitate the exchange of information on water resources and environmental research and education, and on international development and training. The workshop will create a forum for collaborative and joint development and exchange of curriculum to enhance education and research programs.

d) To increase the production of minority Ph.Ds in water resources, environmental sciences and engineering fields. Promising students can be selected from the institutions that collaborate in the program. Services and fellowships will be planned for minority students to provide a supportive environment during their graduate school years and increase the range of career professional opportunities open to them upon graduation.

e) To establish possible linkages with African universities with programs in water resources and environmental management education, training and research.

3. SURVEY FINDINGS

This section briefly documents the on-going research and education activities in the institutions that responded to the survey questionnaire. Important recommendations and suggestions provided by those institutions on the collaborative program are also presented. The possible technical areas of engagement in the collaborative program are listed.

During the planning phase of the consortium, a detailed survey on the capabilities and resources of the collaborative HBCUs and MIs will be conducted. The definite technical areas of engagement can be identified by the HBCUs and MIs. The collaborative institutions will also be asked to identify, characterize and prioritize their areas of interest during the capabilities and resources study.

3.1 Capabilities of Collaborating Institutions

Colorado State University

Colorado State University has extensive worldwide academic and research experience in the water resources and environmental management fields. Demand for these programs is increasing, especially in developing countries. The number of graduate students studying water resources at Colorado State may be the largest in the U.S. and possibly the world. Colorado State faculty are actively involved in Asia, Africa and Latin America, as well as in the United States.

It is perhaps the international arena where Colorado State has been most active. Colorado State's international water programs started at a high level of activity in Pakistan in the mid-1950s. The goal was to build the institution's capabilities in graduate water education and Colorado State's influence is still felt more than 30 years later in the Peshawar region. Colorado State was responsible for the establishment of the Asian Institute of Technology in Thailand. In 1967, Colorado State established the International School for Water Resources (ISWR) to meet the need for non-degree training in water resources. In the last 21 years, ISWR has organized training programs for over 200 professionals from 50 different countries. In 1988, there were 30 to 50 trainees studying problems such as how to prevent the spread of water-related disease from new developments such as dams, how to manage water quality in reservoirs, how to deal with water problems from urbanization and how to design national water resources programs.

Cooperative agreements have been signed with universities in Latin America and Europe, and numerous collaborative activities have been completed. Examples include: projects to control reservoir operations in water-short areas; educational activities in environmental impact analysis; and transfer of videotape instructional technology in water management. In recent years, Colorado State has concentrated on providing assistance in the management of irrigation systems in developing countries with hunger problems. Colorado State has established the Colorado Institute for Irrigation Management to oversee this activity.

Colorado State University has strong links with other institutions in the development of the programs related to water resources and environmental education, research and training. For example, Colorado State and the International Center for Water Resources Management (ICWRM) of Central State University at Wilberforce, Ohio. a well-established minority institution, have signed a memorandum of agreement to work together on program development in a number of areas. Colorado State would like to expand its networking and mutual support with other minority engineering institutions and to encourage minority citizens to become interested in the fields of water resources and environmental management.

Central State University, Wilberforce, Ohio

The International Center for Water Resources Management (ICWRM) of Central State University was founded as an education and research center in response to growing concerns in Ohio and throughout the world about water supplies failing to meet the needs of the people. The center's efforts are focused on improvement of management practices through a program of education, research and continuing education/information dissemination. Their B.S. Program in Water Resources Management is the first in the United States to provide a comprehensive approach to water resources management at the undergraduate level.

The research program of the ICWRM emphasized interdisciplinary approaches to water resources problems, both in the United States and in emerging nations. It focuses on small scale water management systems where productivity may be increased through maximizing efficient use of available resources. Center research maintains a sensitivity to the importance of combining the social, political, economics and cultural factors with the technical to provide practical solutions.

The ICWRM is organized in a way to facilitate the use of a wide range of resources and opportunities to support water resources management training. The Center is able to call upon all the resources of Central State University as well as the resources of a large number of cooperating universities, state and federal agencies. Of special note is the expertise available on small scale water management systems, irrigation drainage, small farming systems, mapping and groundwater.

Central State University has similar collaboration programs with Utah State University, Ohio State University, Colorado State University and the University of the District of Columbia.

Morgan State University, Baltimore, Maryland

Morgan State University has an on-going research program in water quality modelling using the finite element method and has plans to study advanced wastewater treatment for wastewater renovation and reuse.

Morgan State University has suggested research programs to be included within the collaborative program in areas such as the application of finite element methods in water quality modelling and research on wastewater renovation and reuse (e.g., reverse osmosis).

Alabama A&M University, Normal, Alabama

Alabama A&M University has a Bachelor of Science degree program with environmental science major as well as a Master of Science degree program with allied areas of plant and soil science, etc. The university offers environmental science courses such as soil and water conservation, soil and water pollution, air pollution, soil physics and waste management. Research programs are carried out in the following areas: evaluation of surface mining and reclamation on the water resources in central Alabama including fertilizers and organic waste chemical leaching to groundwater and runoff to surface waters.

No international programs are available yet but a training program is currently being planned. The university has similar collaborative programs with other institutions or a consortium of institutions such as with BPNWL-(DOE) and 1890 Consortium.

Alabama A&M University recommends the following research activities to be included in the collaborative program: use of remote sensing in water resources inventory and management; groundwater and contaminant transport through porous media; tillage effects on surface and groundwater quality; role of macropores in preferential path flow in soil profile; fate of hazardous waste chemicals in the environment; microbal ecology and transformation for hazardous waste cleanup; air stripping of volatile organic compound (VOC); chemistry of hazardous waste; retraining workshop for faculty or existing professionals; expansion of experiments for students; funding of research in specific areas such as revegetation and reclamation and student exchange and joint research programs.

Virginia State University, Petersburg, Virginia

Virginia State University, expressed strong interest in collaborating in the Water Resources and Environmental Management Program. The university is in process of developing a similar program in conjunction with its aquaculture program, to be one of several Centers of Excellence at the university.

The Center of Energy and Environmental Studies is interested in the Minority Support and Collaboration Program. The university is establishing a Center for Environmental Studies, which will also address possible research, educational and training programs in water resources. The university houses a major extension program to serve technological needs in water quality and fish farming. The university sponsors research in the areas of water quality, impact of non-point source pollutants on groundwater, aquaculture, hydroponics, air pollution and water treatment. The agency for International Development in cooperation with several countries in Africa and South America have sponsored long-term research through the university. The Center provides a university-wide multidisciplinary program cutting across engineering, science and agriculture.

The Center recommended the forming of an Advisory Council with representatives from minority institutions to provide long-term planning and regular review of the program. The Center also recommends the forming of a consortium of collaborating institutions in water quality research and education. Recently VSU has taken the lead in the planning of the consortium of HBCUs/MIs jointly supported by Colorado State University.

Tennessee State University, Nashville, Tennessee

Tennessee State University does not have water resources and environmental management research programs; but, some research activities related to water and environmental programs are carried out through the Agriculture Research Programs. The research is mainly concentrated on the effects of deep irrigation and landscape plant production. There is a training program on watershed management. The international outreach is mainly on tourism and national park development training.

One suggestion provided by Tennessee State University with respect to the collaborative program is to include water quality and natural resource conservation research.

Recently, many HBCUs and MIs have expressed interest in the collaborative program by sending participants to the conference and workshop held at Colorado State University campus. These institutions are: **Tuskegee University, Southern University at Baton Rouge, Louisiana, Clark Atlanta University, Florida International University, North Carolina A&T University, Norfolk State University and Albany State College, Albany, Georgia.**

3.2 Technical Areas of Engagement

Various areas of engagement and collaboration in research, training, education, studies and services can be identified by the Consortium on Water Resources and Environmental Management of Historically Black Colleges and Universities (HBCUs/MIs). Typical fields of study and some exemplary topics can be listed:

* Socio-economic Policy areas as it affects the water resources and the environment, political issues, legal issues, etc.

* Environmental Policy and Legislation.

* Integrated Impact Assessment - traditional environmental impact analysis, forecasting, risk analysis and management of uncertainty, Environmental Impact Assessment (EIA), etc.

* Conflict Management - alternative dispute resolution techniques, public involvement and participation and transboundary water issues.

* Water Resources and Environmental Management Areas

  - Water Agency Administration
  - Water Quality Management (surface and groundwater quality)
  - Irrigation Systems Management
  - Infrastructure and Public Works
  - Irrigation and Drainage
  - Hydrology and Groundwater
  - Surface Water (quantitative and qualitative assessment, monitoring, measurements, protection, reuse, etc.)
  - Groundwater Resources (modeling, contamination, development assessment, quality monitoring, etc.)
  - Hydraulic and Water Resources Engineering
  - Water Supply and Wastewater Treatment
  - Water quality and impact of non-point source pollutants on groundwater
  - Wet Lands (identification, management, protection, development and use, monitoring, etc.)

- Extreme hydrologic events - short-term and long-term of floods and droughts
- Industrial applications of water (cooling water, water usage in processes, power generation, etc.)
- On farm - water use and management
- Air pollution and Acid Rain
- Solid and hazardous waste management
- Forestation and deforestation
- Land use
- Soil conservation and water management
- Limnology
- Lake restoration
- Best Management Practices (BMPs)

* <u>Computer-Aided Water Management</u>

  - Multi-purpose planning and management
  - Hydrologic and reservoir systems analysis
  - Operational hydrology
  - Mathematical modeling

* <u>Decision Support Systems</u> - The integration of computer information systems, expert systems and modeling to improve subjective judgement.

* <u>Macro-engineering</u> - The study of complex, large-scale systems, comprehensive management and alternative organizational schemes.

* Other sciences of water (recreational, endangered species, aquatic sciences, marine science,legal, economical and political issues).

* Water Resources and Environmental Knowledge Transfer conference and workshops for retraining faculty and existing professionals.

* Student Exchange and Joint Research programs

* Coupling Educational programs in Water Resources and Environmental Sciences and Engineering among collaborating institutions (HBCUs/MIs and Colorado State).

* Faculty Exchange and Research Release Time for minority faculty.

* Scholarship programs for Minority Undergraduate and Graduate Students in Water Resources and Environmental Management (Sciences and Engineering).

* International Education, Training and Research (linkages with African institutions).

* Summer Training and Research Programs.

4. INITIATION OF THE PROGRAM - SUMMER WORKSHOP 1992

4.1 Purpose of Workshop

The conference and workshop will provide persons in the fields of water resources and environment an opportunity to share with other professionals newly developed courses, training programs, outreach methodologies and areas of concern. Leaders in the field of water resources, environment and education will describe broad national goals in each of these areas. While other key persons will address issues in the areas of water resources education, environment education, research, minority education in water resources and environment, international education and outreach.

The specific purpose of the workshop is to provide a forum for participating institutions to exchange ideas on a long-term collaborative program of education, training and research. The workshop will facilitate the exchange of information in water and environment research and education in order to find ways of improving the capabilities of these institutions.

4.2 Agenda of the Workshop

The workshop can address details of the collaborating program in the areas of research and curriculum development, faculty and student exchanges and collaboration on international research, education and training. Other issues such as enrollment and retention of minority students in water resources and environment field, scholarship for attracting minority student, increase the production of minority Ph.Ds are subjects that are addressed by papers presented in the conference. Practical action plans are needed to address and implement these programs.

The main agenda of the workshop is to discuss and plan the establishment of the Consortium of the HBCUs/MIs in Water Resources and Environmental Management. It is necessary that a consensus is reached by the collaborating agencies on the consortium's organization and operational management. This faculty Summer Workshop will be business-oriented intended to produce results and develop mechanisms to carry out long-term programs as envisaged by the consortium.

5. POLICY IMPACT EXPECTED BY THE PROGRAM

The impact of this program will be felt mainly by the HBCUs and the other educational institutions with dual interest in educating minority citizens and developing programs in water resources and environmental education. There will be, in addition, some impacts on those federal agencies with water missions that have the potential to contribute to water and environmental education (4). The expected impacts of the program will include:

* joint development and exchange of curriculum on water resources and environmental management education;

* raised awareness among HBCUs of the potential to enhance their programs with water and environmental offerings;

* increased awareness among minority citizens of the opportunities available in fields related to water and environment;

* identification of opportunities among minority institutions in U.S.A. and institutions in developing countries with new initiatives in water and environmental education;

* demonstration to universities and water agencies of mechanisms to become involved with minority institutions in water and environmental related curricula;

* establishment of a cooperative network of collaborating individuals and institutions for continuing to work on expanding the objectives of the program;

* development of mechanisms to foster coupling of educational programs at Colorado State University and counterparts in HBCU institutions;

* improvements in minority/diversity enrollment, recruitment and retention at the collaborating institutions resulting in more minority Ph.Ds;

* increase in production of Ph.Ds among minority groups in water resources and environmental studies;

* improvement of education in water resources and environment and strengthening of minority institutions (capacity building);

* possible renewal and upgrading of faculty from minority institutions through workshops and research cooperation;

* establishment of linkages with African universities with programs in water and environmental sciences and engineering;

* enhancement of environmental equity as the new environmental awareness and initiative.

6. CONCLUDING REMARKS

The ultimate goal of such collaborative program must be in the capacity building of the HBCUs and MIs in the high priority field of water resources and environmental management. The goal set can be achieved by a concerted efforts of the collaborating institutions and supporting federal agencies with missions in water and environmental management.

The Consortium of the HBCUs/MIs in Water resources and Environmental Management that is being initiated may be the most acceptable and recognizable mechanism to implement the collaborative efforts. Proper planning of this consortium is necessary by these collaborating institutions to ultimately achieve the goal set by the collaborative program.

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SESSION XI PLENARY

MINORITY EDUCATION IN WATER RESOURCES AND ENVIRONMENT

MENTORING-THE KEY TO ATTRACTING AND RETAINING MINORITIES AND WOMEN IN COLLEGIATE ENGINEERING PROGRAMS

BY BRADFORD S. PRICE, P.E. (1) AND MARY ELLEN CHAFIN (2)

INTRODUCTION

The key to success in attracting and retaining students from underrepresented groups in collegiate engineering (or other) programs is mentoring-being a friend and tutor to the students. Most importantly, you have to be a genuine friend.

To increase the potential for success, mentoring should begin at an early age (Grade 5) and continue through college. And, it must be a cooperative effort between students and parents, teachers, school administrators, local, state and federal governments, local junior colleges and college/universities, local industries, and engineers and scientists individually and collectively through the organizations they work for and engineering professional societies.

This paper will present how the Buffalo District, Corps of Engineers (Buffalo Corps) and the Buffalo Section of the American Society of Civil Engineers (ASCE) have worked with the Buffalo-area Engineering Awareness for Minorities (BEAM) organization since 1982 in the development and implementation of a program in Western New York that brings together these various interest groups with a common goal of increasing minority and women representation in engineering career fields.

BEAM BACKGROUND

BEAM was conceived in 1982 in a series of meetings initially convened by the Linde Division of Union Carbide, the State University of New York at Buffalo (SUNYAB), and the Omega Psi Phi Fraternity. The BEAM program received enthusiastic support from the Buffalo Board of Education and the Buffalo Public School professional staff and later from the same groups in the Niagara Falls school system. Local industry has committed funding and manpower for the support of the program. Since its inception, valuable technical assistance for the formation and development of an effective program has been provided by the National Action Council for Minorities in Engineering (NACME) who is leading a national effort to increase minority representation in engineering colleges.

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BEAM is a registered not-for-profit corporation with operation and control vested in its Board of Directors. Engineering employers, science and mathematics based career employers, foundations and educational institutions may become supporting members of BEAM. Government organizations and community groups involved with engineering or technical education and professional societies may become community members. Each member organization is represented on the Board of Directors

BEAM began its program by establishing BEAM Clubs at three city of Buffalo High Schools and placed resources of participating BEAM companies at their disposal. Resource units relating mathematics and science principles to procedures used at the participating industries were developed for Club use. Engineering mentors from industry worked with students at regularly scheduled times after school or during the school day. The program is designed to link schools with local companies for demonstrations, presentations, field trip activities, hands-on projects and role models to provide students and teachers with a better understanding of engineering.

BEAM also assists in defining high school courses required for admission to college engineering programs, provides encouragement and identifies sources of tutorial support for participating students and serves as a center for scholarship information. Teachers receive assistance in the development of more effective curriculum, career education activities and in development of methods for applying classroom learning experiences to the solution of engineering problems.

BEAM works closely with parent groups, community and professional organizations and collegiate institutions to enlist support for the program. Erie Community College , Buffalo State College, Canisius College, and the SUNYAB are participating educational institutions. The BEAM program provides qualified students who may choose to enter the engineering related programs at these institutions. Students are given opportunities to visit college campuses to familiarize themselves with engineering program offerings, to observe research activities and to consult with engineering students and professors. Activities help to develop good reading and communication skills and provide students with information on local engineering career opportunities.

Today, there are over 30 companies and 28 educational institutions who provide over $150,000 in financial/in-kind service support to BEAM as part of an overall operating budget of approximately $220,000. These resources are used to conduct programs at 28 schools and other locations to over 440 students (11% 5th & 6th graders; 56% 7th & 8th graders; 22% 9th and 10th graders; and, 11% 11th and 12th graders. The ethnicity of the students consists of 50% Black, 9% Hispanic, 5% American Indian and 36% Other. There are 31 BEAM program graduates currently enrolled in colleges and universities.

BEAM LONG RANGE STRATEGIC PLAN

Program Goals And Objectives--A long range strategic plan has been developed to provide a more comprehensive program offering for BEAM students to enable them to fulfill their academic and career aspirations. The goals and objectives of this program include: (a) To provide students with an "experience based" educational model that will introduce them to engineering, science and technology careers; (b) To stimulate student interest in science and mathematics through creative projects which will emphasize mathematics and scientific principles; (c) To provide students with role models in engineering, science and mathematics who will not only disseminate information but who will offer encouragement. Student response would be measured as to impact of the mentoring experience; (d) To provide students with the skills necessary to write effectively and present information to the class with a degree of confidence. Also, to teach the study skills required for effective learning and retention of material; (e) To expose students to further opportunities to develop their interest in engineering through the continued participation in various BEAM program activities; (f) To develop a core of students who will enter other BEAM programs and become the basis for tracking the development of student interest in engineering as a career. These students would receive continual career guidance; (g) To provide career guidance as the student progresses through his/her high school career with an emphasis on choosing the courses needed to enter college in the various professions, and workshops which are timed to better prepare the student to take PSAT and SAT exams; (h) To provide an internship experience for post-12th graders with one of the sponsoring companies involved with BEAM to enable students to have a work experience related to their intended career goal; (i) To assist the student throughout his/her college career to increase retention, through the use of workshops, tutors and mentors; and, (j) To facilitate student transfer between colleges and universities to enable the student to receive every opportunity to develop to his/her full potential. These goals and objectives will be met through the following programs.

Beam Clubs--Clubs are an after school activity for 7th through 12th grades that provide: (a) Modules designed for specific grade levels which incorporate mathematics and science principles and hands-on experience; (b) A mentoring relationship between the faculty advisor, and technical leader who act as role models, and the students; (c) Field trips which provide opportunities for students to observe engineers at work; (d) Election of club officers to teach responsibility and provide opportunities to interact; (e) Club competitions to foster creativity, healthy competitiveness and to prepare them for intraclub contests; and, (f) Participation in the school, county or state Science Fairs. Students would be encouraged to do a module that would qualify for these fairs. Future plans include expansion into additional schools including several suburban test sites. Also, a new element will be an all-day BEAM event for all BEAM Clubs called "BEAM Day". This event will have contests including; bridge building, egg drop, kite flying, quiz bowls, poster contests and public speaking. Students and parents will be invited and the event will conclude with awards in all categories.

Summer Programs--Each Summer Institute is compromised of five component parts: (a) Mathematics Enrichment; (b) Science Enrichment; (c) Communication Skills; (d) Computer Science; and, (e) Career/Personal Development. These five components provide a complete enrichment package which enhances the school-year curriculum. BEAM currently has and will continue to have Summer Institutes at these sites: (a) Post 8th grade attends Erie Community College; (b) Post 9th grade attends Canisius College; (c) Post 10th grade also attends Canisius College; (d) Post 11th grade attends SUNYAB;

and (e) Honors Research for 9th through 11th grade at SUNYAB. The Summer Programs run for three to six weeks depending on grade level and include field trips and guest speakers. They conclude with a student-produced newsletter/video and an awards ceremony for parents and industry representatives. Future plans include expansion into Niagara Country with Niagara Community College and Niagara University participating. This year, 1992 will see the addition of a new Honors Research program in Physics at Canisius College. Similar programs at Erie Community College might be added in Robotics or at other sites as need dictates.

Saturday Academies--Saturday programs would be structured to provide high school students with opportunities to explore many different facets of engineering and technology through field trips and guest speakers. A typical ten-week program would look like this: (a) Week 1-Orientation; (b) Week 2-A visit to SUNYAB, including the Earthquake Center and Engineering Labs; (c) Week 3-A visit to the Buffalo Corps including a trip to one of their current projects; (d) Week 4-A visit to ECC including the Robotics and Opthalmic Departments; (e) Week 5-A visit to the Niagara Power Authority; (f) Week 6-A visit to CC including the Physics Labs; (g) Week 7-A visit to Calspan including the Wind Tunnel and Crash testing Sites; (h) Week 8-Panel discussion with Engineers and Technologists from different disciplines, e.g., Mechanical, Aerospace, Electrical, Chemical, etc.; (i) Week 9-A visit to a Ford or General Motors Plant; and, (j) Week 10-Closing with Job Readiness Seminar. The purpose is to provide additional enrichment and expose the students to as many different engineering and technology disciplines as possible. Visiting the sites would allow the students to ask questions relevant to the professions and stimulate interest. This program would be for sophomores and juniors in high school who have decided to follow an engineering or technology path but who would benefit from additional information. As student interest is identified and categorized, Saturday Programs in specific disciplines such as Physics, Robotics, Astronomy, etc. would be developed in the future to offer introductions to these subjects.

Enrichment Classes--Models have been developed to assist students with their in-school curriculum. They are: (a) CMSP-This model accelerates the timetable for students to complete a course in Pre-Calculus during their high school career. BEAM has already completed extensive planning to implement this program in the Buffalo Schools when monies and timing permits; and (b) ENGINEERING CURRICULUM-New York State has developed a Pre-Engineering Curriculum for high school students which would provide classes needed for entrance into a college Engineering Program. This would give students a head start on their program. BEAM's role in both of these programs would be to act as a liaison between the designers of the program and the school system to ascertain feasibility. Both programs are important in terms of better preparing students to enter rigorous college curriculums.

Fifth and Sixth Grade Programs--This program is designed to stimulate student interest in science and technology at the lower grade levels. The fifth and sixth grade programs are designed similar to BEAM Clubs but with more hands-on materials and modules geared toward that particular age group. BEAM currently has three 5th and 6th grade programs. Future plans would include not only additional clubs but tie-ins with existing programs like Boy and Girl Scouts. For example, students might use their BEAM experience to complete one or more badges required by the Scouts.

Community Outreach Program--Special seminars at Community Centers would be presented to provide a community presence to Hispanic, Black and Native American populations and allow us to reach students who would not otherwise be able to participate. These seminars would: (a) Take place on Saturday mornings; (b) Have representatives from The National Society of Black Engineers, Society of Hispanic Engineers of AISES (American Indian Society) to facilitate them; and, (c) Provide career information and demonstrations regarding engineering and technology careers.

Internship Program--An Internship Program, sponsored by BEAM and its participating companies would: (a) Provide Summer Internships for post 12th grade and college students who are enrolled in an Engineering/Technology Curriculum; (b) Provide BEAM participating companies with a resume portfolio of prospective interns; and, (c) Provide Job Readiness Seminars for participating students to teach interviewing skills, proper dress, instructions in filling out job applications, etc. The ultimate goal is to be able to provide a summer internship for every student who wanted one and a summer intern for every company that needs one.

Module Fair For Technical Leaders--To prepare BEAM technical leaders for the onset of the BEAM Clubs during the school year, a "Module Fair" would be held prior to the first club meeting to introduce the leaders to new modules and provide a forum for interaction between "old hands" and "newcomers". The technical leaders themselves would host displays of modules they have used effectively and answer questions regarding problems and solutions.

Teacher Training--Several opportunities might be provided for BEAM faculty advisors to enhance their knowledge. They are: (a) Internships-Many corporations will provide internships during the summer for teachers. These provide an opportunity for teachers to observe first-hand the operation of a business or industry and allows the industry personnel to interact with the teachers. These internships have proven very successful; (b) Seminars-Discussion with the SUNYAB regarding seminars for BEAM teachers in Mathematics and Science enrichment. Teachers would receive credit for these seminars; and (c) SECME Institute-SECME hosts a week-long seminar each year for teachers from NACME-sponsored organizations. Until BEAM has not had funding to sponsor an outstanding teacher to attend one of these sessions, but hopefully in the future they will.

THE BUFFALO DISTRICT CORPS OF ENGINEERS AND AMERICAN SOCIETY OF CIVIL ENGINEERS MINORITY PROGRAM ACTIVITIES

History--The Buffalo Corps became involved with BEAM in 1982 through the Army's Adopt-A-School Program by providing engineers to assist in presenting technical programs to BEAM Clubs. Around 1985 they expanded their involvement and identified a Technical Leader to lead a Club at one elementary school and in 1986 they took over responsibility for a Club at a senior high school. Concurrently, the ASCE also began its involvement with BEAM through its members who served on the faculty of the SUNYAB by donating funds to BEAM for the SUNYAB Engineering Summer Honors Research Program. High school students worked with Professors of Civil Engineering during the summers on research projects.

Organization--Significant planning was accomplished in the summer of 1988 to expand the Buffalo Corps and ASCE involvement in minority programs. It was recognized that civil engineers, many of whom were ASCE members, and other employees of the Buffalo Corps and other engineers affiliated with the ASCE had been actively involved with minority programs with both groups since 1982. Efficiencies could therefore be gained by coordinating the efforts of both organizations and expand their involvement in future years in many areas including: (a) BEAM Clubs; (b) Girl Scouts; (c) Engineer's Week Program; (d) Engineering Explorer Post; (e) Summer Institutes; and, (f) Internships Program. Program accomplishments in these areas are presented below.

The combined programs of both organizations were first administered by the ASCE through a Minority Programs Committee Chairman (MPCC). The Technical Leader of the BEAM Clubs from the Buffalo Corps served as the first Chairman of the MPCC. The combined program is submitted annually by the MPCC to the ASCE for review, comment and approval. Funding requests were included in the annual budget which is then ratified by the membership. Funding requests were also submitted to the National ASCE HQ, Committee On Minority Programs (COMP) and the Buffalo Post of the Society of American Military Engineers (SAME).

The MPCC's primary responsibility was to coordinate the minority programs of the Corps, ASCE and SAME. The MPCC was also responsible for interfacing with the BEAM organization as a member of their Executive Committee and Board of Directors and Chairman of the BEAM Community Involvement Committee. Opportunities for an interchange of ideas and information to improve BEAM program operations resulted.

Program Accomplishments, BEAM Clubs--The BEAM Clubs targeted children in grades 5 through 8 at a grade school and grades 9 through 12 at a high school. Students were introduced to engineering through a variety of lectures, tours and construction of scale model projects. Approximately ten other engineers, scientists and other professionals from the Buffalo Corps and ASCE assisted in various capacities throughout the year.

The Fall program began for 70 students with a boat tour of the Buffalo waterfront area along Lake Erie and the Niagara River. A number of civil engineering projects were viewed including bridges, grain elevators, water and waste treatment plants, navigation canals and lakes, etc. Engineers and scientists from the Corps provided background information about project design, construction and operation. Three other field trips were conducted during the year including: (a) A tour of a coal fired steam electric plant; (b) A tour of a Geotechnical Lab; and, (c) A tour of a Nature Preserve where environmental principles and the role of the engineer in protecting and enhancing the environment while meeting societies needs were presented and discussed.

Various scale model projects were constructed by the students during the year with technical guidance and direction provided by civil engineers. These projects included kite construction from scratch and scale model bridge, tubular truss and breakwater construction. The projects were displayed and entered into competition during daytime Engineer's Week activities in February 1989 and at the Erie/Niagara Chapter of the New York Society of Professional Engineers (NYSPE) annual banquet.

Educational materials provided by Niagara Mohawk were used to introduce students to electrical power and energy generation by various means including conventional and pumped storage hydropower. Alternative sources of energy and the safe use of electricity were also discussed. Two computer programs developed by the New York Power Authority provided hands on experience in budgeting finances and kilowatts in a home and community, respectively.

An essay contest was sponsored by the SAME. Savings bonds were awarded to one student from each grade, eighth through twelfth, for the best essay on the subject of "The US Constitution-What It Means To Me".

ASCE members presented information about civil engineering during local High School Annual Career Day activities and during the SUNYAB Sixth Annual Science Exploration Day activities.

Girl Scouts--Approximately 500 copies of the ASCE coloring book titled "Would You Like To Be An Engineer?" were donated to the Girl Scout Council of Buffalo and Erie County. They were used by Scouts working toward their "Putting Things Together" badge with assistance from civil engineers.

Engineer's Week--Projects constructed by the students were displayed during Engineer Week activities. Students were on hand to answer questions from the public. Copies of the ASCE coloring book and coloring and activity books from the Niagara Mohawk Power Corp. presenting electricity generation and natural gas production were distributed to the public. Video tapes presenting civil engineering as a career choice were shown. Brochures describing civil engineering and where to obtain more information regarding careers were disbursed. Scale model bridges were tested in competition with entries from other schools. Finally, two students and their parents were honored for outstanding achievements in the BEAM Clubs by the Erie/Niagara Chapter of the New York Society of Professional Engineers (NYSPE) at their annual banquet.

Engineering Explorer Post--The SAME sponsors the Boy Scouts of America Engineering Explorer Post 76. The program is administered by employees of the Buffalo Corps. The Explorers were introduced to a broad range of engineering and technology principles through various activities including tours of a Naval landing craft, the UB earthquake center, the UB geotechnical testing lab, the UB nuclear testing lab, the Univ. of Rochester laser lab, the Rochester Institute of Technology printing school and IBM. They also attended a computer show and career fest at the Buffalo Convention Center. ASCE provided funding for purchase of materials for scale model bridge and rocket construction projects. The model rockets were launched during a picnic that was attended by Armenian children, their guardians and interpreters. They were living in the Buffalo Ronald MacDonald House temporarily while some received treatment for injuries sustained during the 1988 earthquake in Russia. They also attended the Buffalo Corps Annual Engineer Day Picnic under the sponsorship of the SAME.

Summer Institutes--BEAM annually selects approximately one hundred academically talented high school minority students to participate in six Summer Institutes at three colleges/universities. Buffalo Corps and ASCE members assisted in the conduct of these programs by providing lectures, tours and work shops. The MPCC conducted a campaign to raise funds from local AE, construction and other firms to support these programs. Three minority students who participated in the BEAM Clubs received partial support through this effort. Two students participated in the Honors Research Program performing research using Computer Aided Design programs and one student completed the Pre-College program, focusing on architecture/civil engineering.

Internship Program--Graduating high school students who meet academic and income qualifications are being placed with local participating civil engineering firms and work during school vacation periods (summer, Christmas, and Easter) during their four years at college. The Buffalo Corps hired four students who are rotated through the Planning, Engineering, Construction-Operations and Support areas during the four years to gain the broadest perspective possible about the functions of the organization.

CONCLUSION

The BEAM program and efforts by organizations like the Buffalo Corps of Engineers and the American Society of Civil Engineers are testimonies of what can be accomplished to increase minority representation in engineering career fields. Mr. Dexter Johnson was one of the first graduates of the BEAM program. He summed up his feelings about the program in a letter that was published in BEAM's 1990 Annual Report as follows:

"In pursuing a degree in the engineering field, or any other degree, it is very important to keep yourself focused on what you want to accomplish. There is no guarantee for success but there is a guarantee for failure if no attempt is made to work hard towards a goal.....I realized that being persistent and not giving up had allowed me to reach one of my goals. I must add that I didn't do it by myself. It was with the help and support of my family, friends, and organizations like BEAM and the National Society of Black Engineers (NSBE) that I was able to make it. I graduated with a Bachelors of Science degree in Aerospace Engineering in 1987."

Mr. Johnson went on to complete a Masters Degree in Mechanical Engineering in 1989 through a research fellowship from the NASA Langley Research Center. He is currently working toward his PhD and will work for NASA upon graduating. His dream is indeed coming true as are the dreams of hundreds more who are following in his footsteps. Mentoring is indeed the key to success.

"Minority Engineering and Research Project"

by

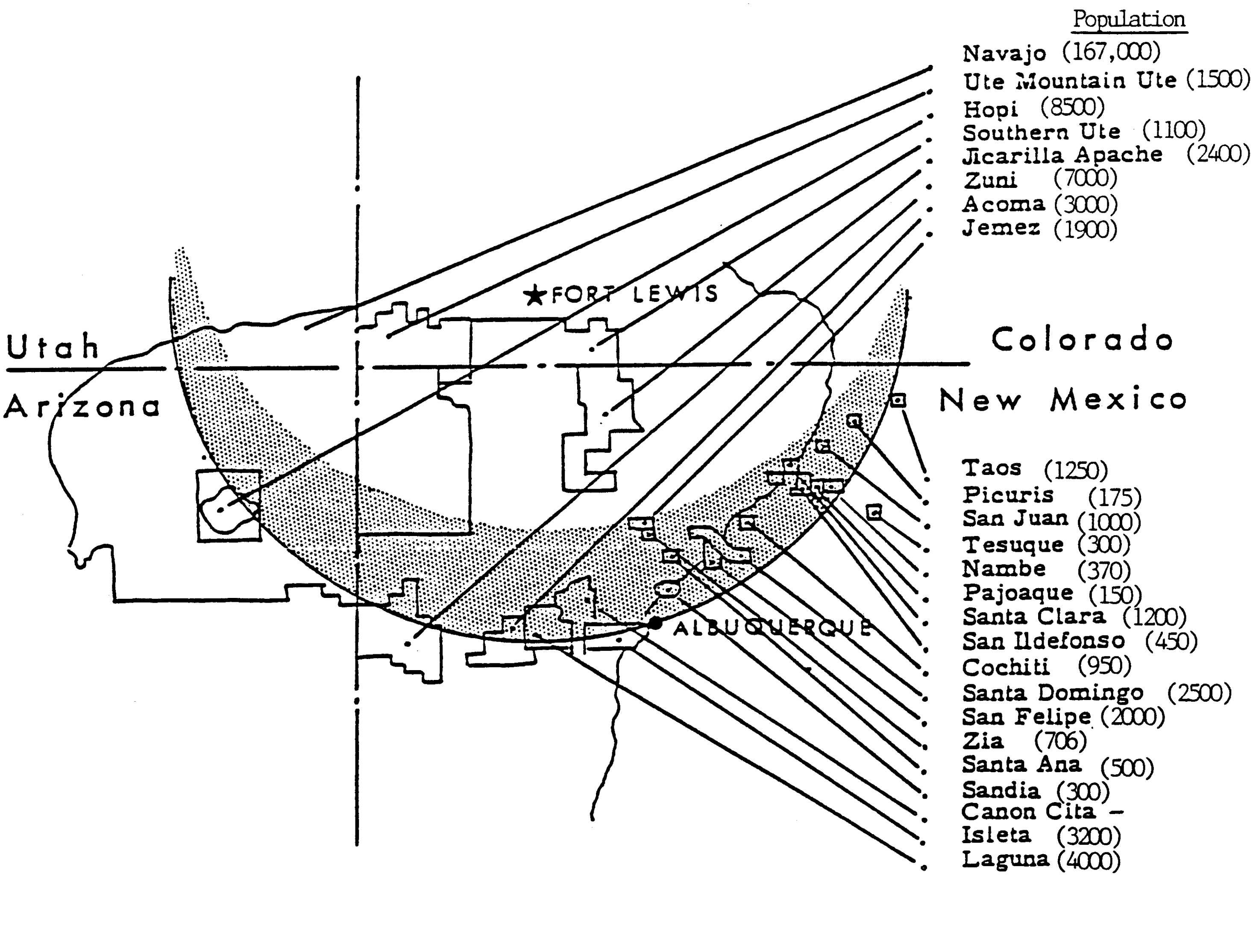
Omnia El-Hakim[1]

Submitted to Water Resources and Environment:
Education, Training and Research
Colorado State University

[1]Associate Professor of Civil Engineering, Fort Lewis College, Durango, Colorado 81301, (303) 247-7160. Principal Investigator of "Minority Engineering and Science Project" National Science Foundation Grant.

Figure 0

INDIAN RESERVATIONS WITHIN 150 MILE RADIUS of FORT LEWIS COLLEGE



Background & Motivation

Minorities are significantly underrespresented in science and engineering fields in the United States. To attract and retain capable minority students will require the development of programs which motivate and encourage them toward science and engineering. Projects which are designed to involve students in hands-on research activities under the guidance of practicing professionals can provide this type of nurturing and challenging environment.

An area in need of a renewed research focus is irrigated agriculture. Irrigated agriculture plays a pivotal role in the production of the food and fiber needs of a growing world population. However, as the world becomes increasingly dependent on the production of irrigated lands, irrigated agriculture is facing serious challenges that threaten its sustainability. Research is needed to develop systems to represent, analyze and assess the vast amounts of physical and economic data needed to approach optimum management of large-scale irrigation systems.

Regions facing especially acute problems in management of irrigated agriculture are the Indian reservations of the western United States. A system sharing many of the cultural distinctives of the reservations but which has enjoyed a measure of economic success is that serving the Navajo Agricultural Products Industry (NAPI), south of Farmington, New Mexico. Since NAPI is owned and operated by the Navajo Indian Tribe, the irrigation system provides an excellent setting in which to train Native Americans and other minority students in the development of a computational environment to support effective resource management.

Objectives & Approach

To develop and implement a resource management support system for irrigated agriculture with the NAPI. Such a system would link modern information systems (database, simulation, visual and interactive display) with facilities for monitoring and regulating water control to effectively meet farm water requirements. The project has the following distinctive objectives:

- Increasing the understanding and effectiveness of problem-solving, information processing and decision-making analysis related to water, land, human resources and environmental protection for irrigated agricultural systems.

- Training and encouraging Native American, Hispanic and other minority students to complete undergraduate work in science and engineering and pursue careers in the development and application of technology to improve resource management.

- Implementing a teamwork learning environment that includes undergraduate students, graduate students, faculty and professionals from an outside corporation (NAPI).

- Implementing summer camps for high school and middle school students and a regional conference for high school and community college students to motivate and interest them in science and engineering.

Cooperating Agencies

Partial support for graduate students from NAPI; matching funds, equipment and release time support from the Colorado State University System; endorsement from the American Indian Science and Engineering Society.

This project is designed to involve students in hands-on research activities under the guidance of practicing professionals and faculty members. Resources of the university system (Colorado State University, Fort Lewis College and University of Southern Colorado) and from other sources, such as Industry, NAPI, the Bureau of Indian Affairs (BIA) and the Department of Education, will be provided as illustrated in Figures (1) and (2).

UNDERGRADUATE RESEARCH AND EDUCATIONAL PROGRAM

Philosophy

The under-representation of Native Americans in science and engineering is a dilemma which is rooted in the intertwined elements of educational access, cultural differences and academic preparation. These forces exert themselves on most Native American students resulting in both a limited number who attempt careers in science and engineering and in a high attrition for those who do enter these programs as freshmen. The objective of this proposal is to lessen the impact of these obstacles. This will be accomplished by first taking advantage of the very unique relationship Fort Lewis College has with the Native American community. This includes;

1. Close proximity to numerous reservations.
2. Faculty with experience in working with Native Americans.
3. An established Native American Center on campus which provides various forms of support.

Because of these factors Fort Lewis College is an ideal school for Native American students to begin their academic careers.

A key ingredient which is missing is a vehicle to give students a meaningful science and engineering experience during the beginning of their academic career as undergraduates. Many Native American students indicate to us that they must see some relevance in what they are doing in order to stay involved. In addition, many are poorly prepared in mathematics and science and must spend several semesters catching up. Unless we have some way of keeping them involved the majority will drop out of technical programs before their junior year.

The proposed portion of the undergraduate research will provide these students with hands on experience in research and applied engineering. Furthermore, the project with

Figure 1

PIPELINE OF THE WORK

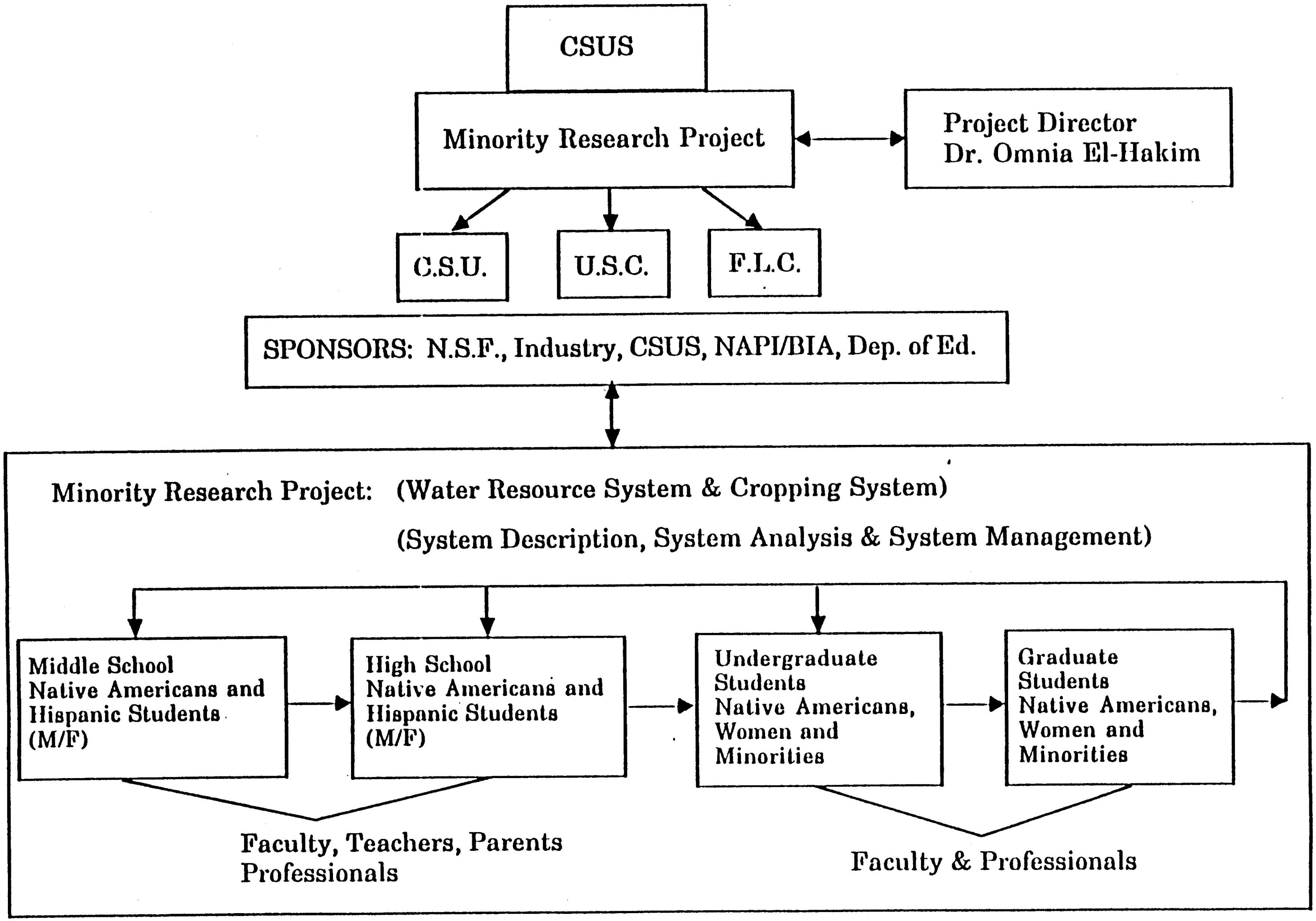
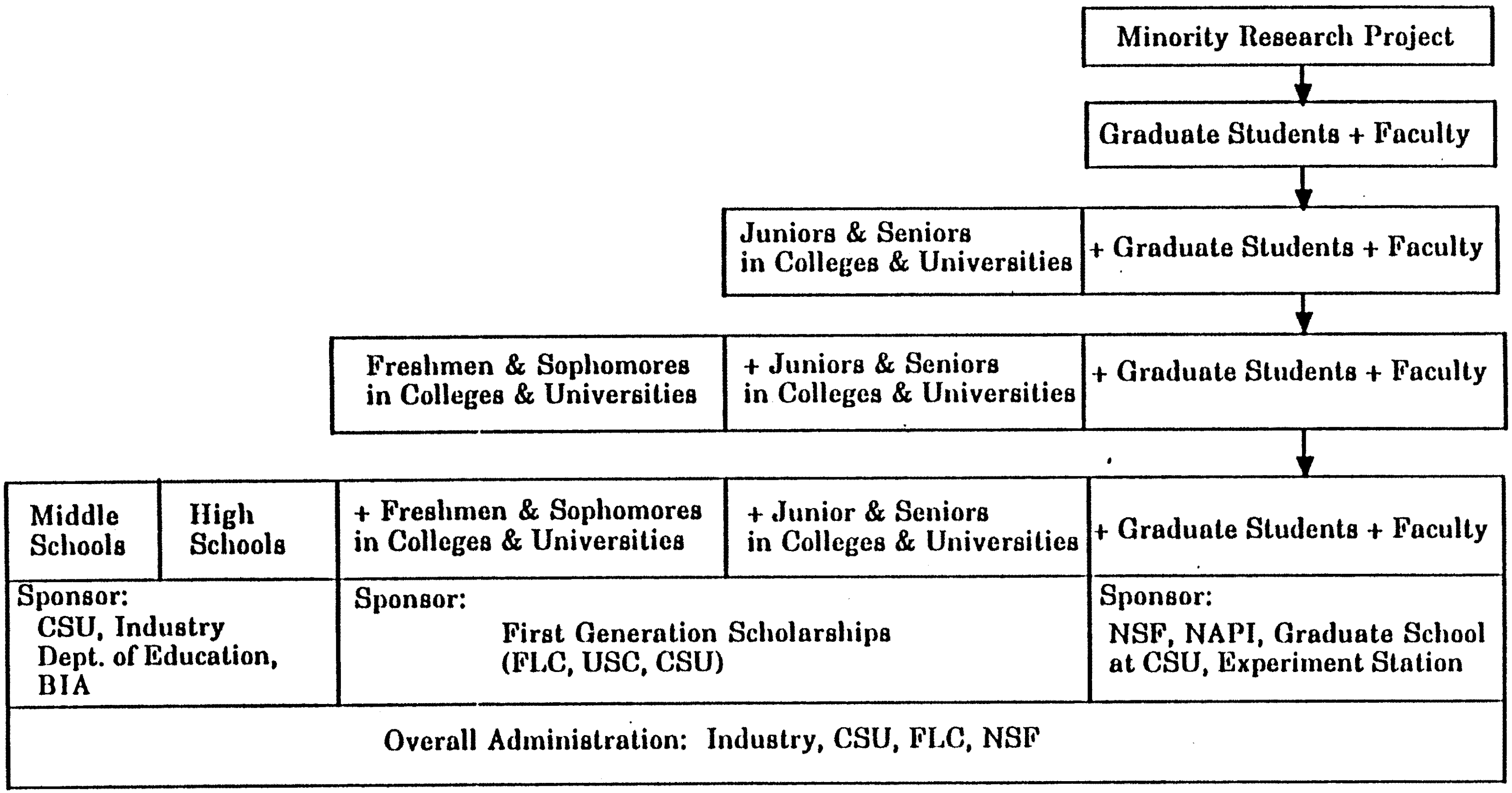


Figure 2

OVERALL CONCEPT

To Illustrate How to Increase the Number of Women and Minorities Utilizing the Research Project.



<u>Funding:</u>

NSF	→ Research Project
Industry CSU System (CSU, FLC and USC) Dept. of Education	→ Summer Camp's costs, regional conferences, scholarships, tuition, summer employment, and promotion costs.
NAPI/BIA	→ Stipend and tuition for graduate students.

NAPI is on the Navajo reservation and will provide a strong tie with their culture further strengthening their commitment.

The central research topic entails the development of a "Decision Support System" to improve productivity of irrigated lands on the NAPI farm. Several associated components of this overall project have been identified by NAPI personnel. Each component will become a research topic for one to three undergraduate students. Students will conduct research as part of teams that will include 2-3 students, a faculty member and one or more NAPI personnel. The size of the target group of students is 13 undergraduate students and 2 or 3 graduate students, as shown in Figure (3). They will be expected to participate in the project on a year round basis, with a concentrated experience during the summer. In return, each student will be given a stipend and college credit for their work. Some of these sub-projects include;

* Development of a Geographic Information System for cropped lands.
* Mapping of irrigation resources.
* Data collection and management.
* On farm water consumptive use studies.
* Environmental chemistry and laboratory analysis.
* Water flow measurement and analysis.
* Plant pathology research and application.
* Monitoring of pesticide contamination of the groundwater.
* Agri-finance investigations.

Over a proposed project duration of five years, project investigators, graduate students and undergraduate students will cooperate with NAPI employees to build an interactive computational environment facilitating access to tools for describing, analyzing, developing and assessing the NIIP system. These activities are essential to making effective management decisions. Resource management decisions to be focused on in this project are those associated with project water resources and cropping systems (See Figure 4)

Expected Outcome

This project will provide an opportunity to test and enhance the suitability of existing information and control technologies for successful management of complex irrigation systems under actual field conditions. Results would be very valuable to the upgrading of similar systems on other Indian reservations, in the western United States and throughout the world. Furthermore, minority students will be trained, encouraged and given hand-on experience in developing appropriate science and engineering solutions to practical human concerns.

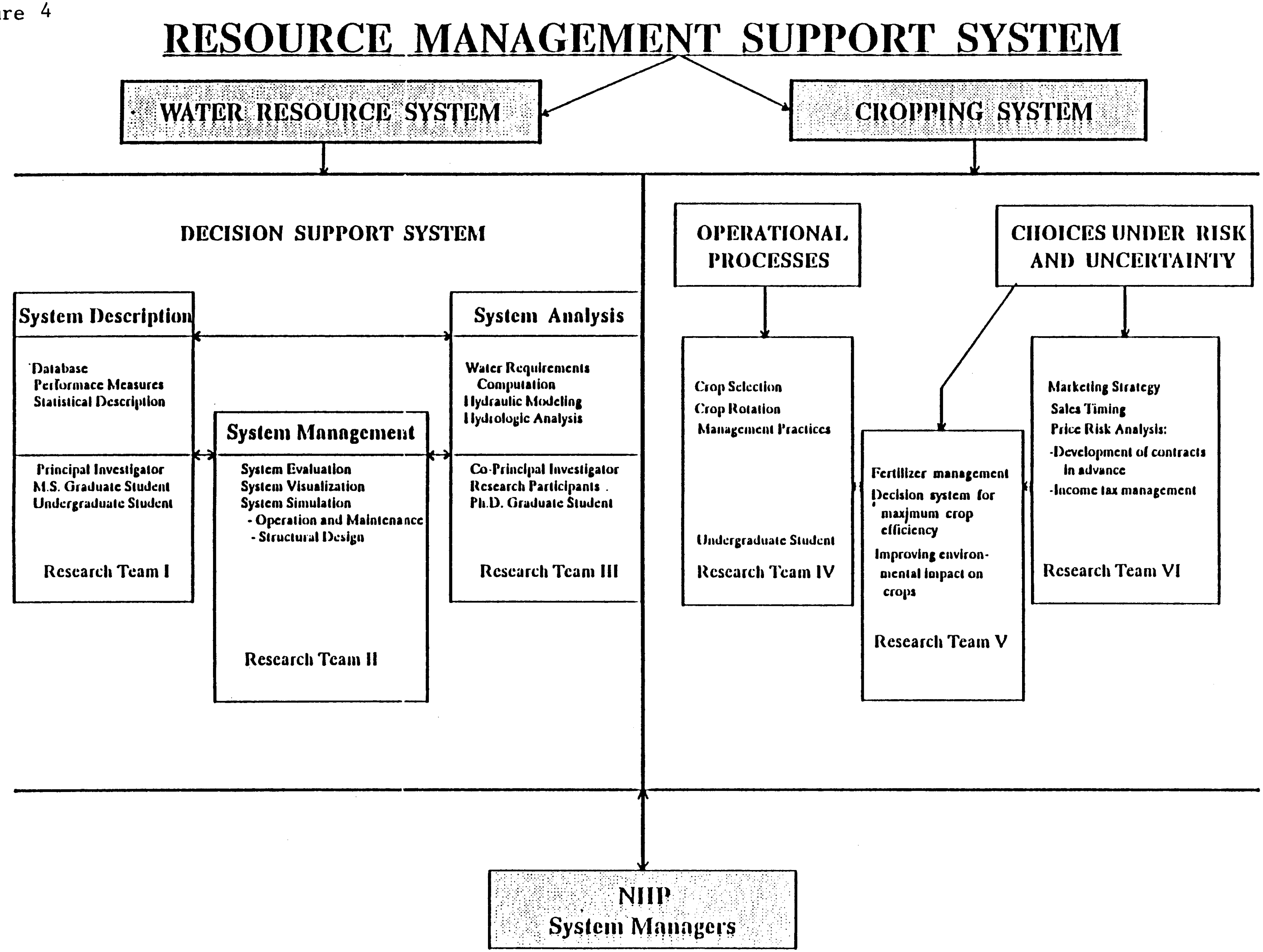
Figure 3

R.C.M.S. - Undergraduate Focus

Project Duration (Total 5 Years)	Avg. No.	Undergraduate Students
1st Year	15	Sophomore
2nd Year	15	Junior
3rd Year	15	Senior
4th Year	10	MSc 1st Year
5th Year	10	MSc 2nd Year
TOTAL	65	

Total Students	Undergraduates	Graduates MSc PhD	Undergraduate
10	9	(1)	
15	9	(2) (1)	3
18	9	(2) (1)	3 3
12	-	(2) (1)	3 3 3
15	-	(2) (1)	3 3 3
67			

Figure 4


RESOURCE MANAGEMENT SUPPORT SYSTEM
WATER RESOURCE SYSTEM
CROPPING SYSTEM
DECISION SUPPORT SYSTEM
System Description
Database
Performace Measures
Statistical Description
Principal Investigator
M.S. Graduate Student
Undergraduate Student
Research Team I
System Management
System Evaluation
System Visualization
System Simulation
- Operation and Maintenance
- Structural Design
Research Team II
System Analysis
Water Requirements
Computation
Hydraulic Modeling
Hydrologic Analysis
Co-Principal Investigator
Research Participants
Ph.D. Graduate Student
Research Team III
OPERATIONAL PROCESSES
Crop Selection
Crop Rotation
Management Practices
Undergraduate Student
Research Team IV
CHOICES UNDER RISK AND UNCERTAINTY
Fertilizer management
Decision system for maximum crop efficiency
Improving environ-mental impact on crops
Research Team V
Marketing Strategy
Sales Timing
Price Risk Analysis:
-Development of contracts in advance
-Income tax management
Research Team VI
NIIP
System Managers

OVERVIEW OF MINORITY STUDENT RECRUITMENT AND RETENTION PROGRAMS AT FLORIDA INTERNATIONAL UNIVERSITY IN ENVIRONMENTAL SCIENCE AND ENGINEERING

Berrin Tansel[1]

Florida International University, a member of the State University System of Florida, opened its doors in 1972 and has grown in its 20 year history to over 22,000 students. It has a large minority student population (over 50%) and it is considered to be a minority institution by the National Institute of Health (NIH), Department of Energy (DOE) and other Federal Agencies. In its genesis of the engineering programs, the State Legislature has directed the University to be a center of excellence in undergraduate teaching and research. Committed to both quality and access, FIU meets the educational needs of traditional students and serves the increasing number of part-time students and life-long learners. In 1989-1990, FIU had more than 19,500 students, 750 full-time faculty and 45,000 alumni, making it the largest public university in South Florida and the fifth largest of Florida's 31 colleges and universities.

For the past three years, FIU has been named in the U.S. News & World Report survey of "America's Best Colleges" as one of the best comprehensive universities in the nation. The University is fully accredited by the Southern Association of Colleges and Schools and is cited in "Baron's Guide to the Most Prestigious Colleges" and Edward Fiske's "The Best Buys in College Education."

In 1991/92, FIU had more than 23,300 students, 800 full-time faculty and around 50,000 alumni, again making it the largest public university in South Florida and the fifth largest of Florida's 31 colleges and universities. Of the total student body, almost 45% are Hispanic, 10% are African American, and 3% Asian. International students represent approximately 5% of the student population.

FIU has one of the largest Hispanic enrollments in the nation. During the 1989/90 academic year, the School of Engineering graduated more Hispanic engineers than any other engineering school in nation. Additionally, each of the six engineering programs (civil, computer, electrical, environmental, industrial

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and mechanical) in the School of Engineering ranks in the top ten in numbers of Hispanic student enrolled within their respective engineering disciplines. Table 1 presents the top ten universities issuing degrees to hispanic students at the gradate and undergraduate level in 1991/92 academic year.

FIU offers a number of programs in the area of environmental science and engineering to increase minority participation. These programs start at the high school level and continue to the graduate level research activities.

The general objectives of student recruitment and retention programs in environmental science and engineering include:

- To increase minority participation in the public, private and non-profit environmental industries
- To increase environmental awareness among minorities
- To increase interaction between HBCU/MI and minority universities
- To improve institutional development in environmental education and research, and
- To increase minority technical businesses in environmental industry.

The current programs to promote science and engineering among the minority students are discussed below.

PRE-COLLEGIATE PROGRAMS

Pre-collegiate programs at FIU provide opportunities for minority high school students to prepare for and to experience college. Eligible minority students receive scholarships to enroll in a variety of summer college classes. Laboratory exercises, test taking and studying techniques are also provided. The Florida Action for Minorities in Engineering (FLAME) is a pre-college initiative that identifies high school students, grades 9th through 12th, to participate in a program that introduces engineering careers. Additionally, students participate in existing research at FIU and an internship program.

MINORITY STUDENT SERVICES

The Office of Minority Student Services provides academic, social, and

TABLE 1

TOP TEN UNIVERSITIES ISSUING DEGREES TO HISPANIC ENGINEERING STUDENTS FOR THE 1991/92 ACADEMIC YEAR

TOTAL HISPANIC UNDERGRADUATE ENGINEERING STUDENTS

RANK	NO. OF STUDENTS	UNIVERSITY
1	885	University of Texas-El Paso
2	714	Texas A&M
3	691	University of Texas-Austin
4	**668**	**FIU**
5	660	CCNY (City College, New York)
6	640	Cal Poly-San Luis Obispo
7	583	New Mexico State University
8	492	Cal Poly-Pomona
9	404	Cal State University-Long Beach
10	361	Texas A&I University

TOTAL HISPANIC GRADUATE (Non-Ph.D.) ENGINEERING STUDENTS

RANK	NO. OF STUDENTS	UNIVERSITY
1	90	Stanford University
2	71	University of Texas-El Paso
3	63	San Jose State University
4	**56**	**FIU**
5	45	Georgia Tech
6*	44	Texas A&M University of Southern California
7	43	New Mexico State University
8	42	Polytechnic University
9	40	CCNY (City College, New York)

* Two or more universities were tied for that rank

cultural support, personal development opportunities, as well as activities and events designed to assist students in achieving their academic goals. The minority student services programs provide assistance in the following areas:

- Advising/placement testing
- Campus/program orientation
- Financial aid
- Student performance monitoring
- Faculty and peer support
- Professional development

DEGREE PROGRAMS

FIU offers an interdisciplinary certificate program in waste management at the Bachelor of Science level. The certificate program curriculum is designed to ensure that future scientists and engineers have the rigorous preparation in a traditional science or engineering discipline while providing exposure to broader issues of environmental problems. The interdisciplinary program requires the students to take four core courses and two elective courses. Electives can be one of the courses involving environmental science and engineering principles for air quality solid waste management, water pollution, nuclear waste management and independent study. In addition, students can pursue graduate level studies in environmental science and engineering.

UNDERGRADUATE RESEARCH OPPORTUNITIES

Funded research opportunities are available to encourage undergraduate students to get involved in the research projects and to encourage graduate studies. Students are encouraged to select their research projects from the ongoing research activities depending on their area of interest. To promote student interest, a list of general topics are discussed and students are encouraged to focus their research ideas once a general area of interest is selected. Depending on the diversity of interest, students who express desire to work on a larger scale problem are encouraged to work as a team to accomplish the various challenges of each phase of the research. At the end of this step, each student has a clearly defined research topic with a specific focus. Students select areas in which they would conduct experimental or theoretical research.

General research topics include: dispersion of pollutants in the environmental, physical and chemical properties of pollutants; water pollution; air pollution, wastewater treatment; hazardous waste treatment; risk assessment;

migration of chemicals; kinetics and chemistry of chemical reactions in the environment; chemical and physical treatment unit processes; biochemical reactions; industrial processes; and model development. Students are given guidance to conduct literature search, explore the state of the research and technology on the research area selected, and encouraged to write technical papers for publication and/or presentation at technical conferences.

CONCLUSIONS

The success of the minority student recruitment and retention programs depends on the following factors:

- Student/supervisor ratio
- Follow up programs
- Transportation/access to the university
- Counseling

The pre-collegiate programs require relatively high student/supervisor ratio and more intensive guidance. Follow up programs are necessary for continued success to attract minority students. Follow up programs could range from reunions to summer coop programs for students who have previously participated in various activities. Transportation is a major limitation as students are requested to provide their own transportation. Therefore, minority programs are most effective for the area students.

SESSION XII PLENARY

MINORITY EDUCATION IN WATER RESOURCES AND ENVIRONMENT

UNIQUE PROBLEMS FACED BY MINORITY INSTITUTIONS EDUCATORS

Emmanuel U. Nzewi[1]

ABSTRACT

The purpose of this paper is to provide a forum for the discussion of problems unique to educators at Minority Institutions with particular regard to instruction and research. This paper could begin a discussion of the issues that affect the quality of education and research at Minority Institutions with the purpose of identifying the best approach to addressing these problems.

INTRODUCTION

This paper is a primer designed to generate discussions regarding unique problems facing faculty at Minority Institutions (MI) similar to the author's, who is a Civil Engineering professor. It provides a brief overview of the primary problems identified by the author through personal experience and informal interviews of other faculty. Its purpose is to briefly describe the problems and to propose solutions which, it is hoped, will facilitate the improvement of the quality of education and research in Minority Institutions -- whose mission includes a balanced approach to education and research. This paper is also intended to provide information to agencies and groups to more efficiently and effectively attain their goals of the improved undergraduate and graduate education and research at MI's. It should be pointed out (again) that the focus of this paper is to identify the difficulties faced by faculty in MI's -- particularly those in institutions whose mission includes the participation in internationally and nationally recognized research activities.

Obviously, certain advantages are enjoyed by faculty in MI's when compared with their counterparts in the major research-oriented universities and colleges. What is presented here are the problems that greatly hinder the effectiveness of educators at Minority Institutions. It is hoped that if these major difficulties or handicaps are resolved, it will result in significant improvement in effectiveness with regard to research and classroom performance. And will concomitantly lead to a higher level of job satisfaction in the faculty body.

In the discussion that follows, unless otherwise stated, comparative statements refer to the major (research-oriented) universities in the United States.

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IDENTIFICATION OF PROBLEMS

Level of Support

The level of clerical and administrative support in Minority Institutions (MI) is generally lower than that found in the majority/research-oriented universities. Faculty at MI's must do most clerical tasks themselves. This includes typing, photocopying, general office management, the management of local area computer networks (LAN) and other low-level tasks required for day-to-day office management such as keeping the books on research accounts.

MI's provide only minimal administrative support for faculty in the development and submission of research proposals. In contrast, for example, in some of the majority/research institutions, administrative personnel assist faculty with the development and organization of the non-technical aspects of proposals for external funding. Some universities even assign university staff to visit the funding agencies to ensure that their proposals are given adequate consideration -- which is generally not the case at most Minority Institutions. Thus, MI's have weaker administrative resources available to support faculty in the pursuit of research grants. This can be a significant disadvantage, especially if the institution is not well-known.

The lower levels of both clerical and administrative support are significant because MI faculty are left with no alternative but to be involved in a myriad of administrative, uncreative details and therefore have significantly less time to carry out their other primary responsibilities. This condition can be crippling for a variety of reasons. First, the weaker clerical support means that MI educators must spend their time on low level tasks, that can be more efficiently carried out by professional office administrators. Second, the lack of administrative support in the development and submission of proposals means that they will generally not submit the best presented proposals. Additionally, they do not have the benefit of an advocate who can represent them in person at the funding agency. Also lost are the benefits of associating a face with a proposal. The lack of basic support significantly handicaps MI faculty because they are involved in every stage of the preparation, compilation and submission of their proposals which means that they have less time to address other more significant issues.

Educational support in the form of human and physical resources is usually not as good as those found in larger schools. Usually, computer resources, audio-visual aids, graduate teaching assistants and technicians are not found at the same levels as at the larger universities. This is generally expected because financial resources and facilities are more limited due to the MIs' smaller size. Graduate students are fewer and graduate teaching positions are not usually supported by the university. If faculty in MI's are to engage in effective research and be able to challenge students with reasonable amounts of homework and projects, graduate teaching assistants are invaluable. This is one of the most significant handicaps of faculty at MI's.

In some cases, as alluded to above, certain instructional and research equipment may not be available at MI's because of the limited financial resources.

For example, the university may not be able to acquire and maintain a supercomputer, or a lab that requires very specialized computer equipment and software. Some faculty in MI's find that they cannot engage in high quality, innovative research activities because the necessary equipment to conduct the required investigations is not available. In some cases, basic computer resources and library materials are not adequate to support either meaningful research or advanced graduate (doctoral) education. With regard to graduate students, the difficulty in attracting good students can impede the research efforts of young, energetic and bright faculty. It can be very frustrating for a faculty to be limited in achieving his/her professional career goals because the basic resources are unavailable.

Generally, research start-up moneys are not provided for new faculty. Because of this, it is very difficult for new faculty to initiate or start new research projects. Because start-up funds are not provided, it is very difficult to pursue research activities in relatively virgin fields or in areas where emerging technologies will be necessary. Since Minority Institutions do not typically have the resources to invest in their faculty, it is usually more difficult for faculty to respond quickly to new technologies and therefore the quality of research may be compromised. Additionally, since the university does not provide start-up research money, faculty cannot engage graduate research assistants to help in the development of meaningful ventures.

Because of the typically smaller school and faculty size, it is more difficult to find other professionals to collaborate with in interdisciplinary research projects. Of course this makes it less probable to solicit for and obtain large, more meaningful research projects. Quality graduate students are more difficult to attract because of the lower visibility of MI's, the money available to hire them and the limited research opportunities that exist at Minority Institutions. Finally, faculty development funds are also limited at MI's.

Teaching load

Teaching load is comparatively heavy at MI's. The typical yearly teaching load (with research activities included) is four (4) to six (6) courses. The lower number (four) is for a faculty who is fully engaged with research activities -- which translates to two courses per semester. In extreme cases, up to seven (7) or eight (8) courses may be taught in a year. The high teaching load is even more tasking in those cases where there are no teaching assistants to assist with the low level course management tasks. In fact, no teaching assistants are provided as they are at the larger institutions. But because promotion and tenure usually require teaching excellence, research excellence, community and service activities, faculty at MI's find it much more difficult to meet these requirements. It is virtually impossible to achieve all of these goals given such a heavy load and so little support. Faculty must work very long hours, for which they are not compensated, just to keep abreast of the teaching, research and service requirements. This usually makes for worn-out and frustrated faculty at the end of the school year. Therefore they can become less focused and of course, less efficient.

Because of the very heavy teaching load during the school year, most research work is conducted during the summer months. Faculty must work at peak efficiency to complete most of the research work during that time and must continue to work long uncompensated hours. If a faculty is worn out during the school year, it is very difficult to produce excellent work over the summer months. It is therefore clear that something needs to be done if a high standard of research is to be maintained (as well as reasonably healthy and satisfied faculty) at the MI's -- perhaps, a reduction in teaching requirements is a very good starting point. This issue will be elaborated upon in the "Solutions" section below.

Perception of MI's: External and Internal

There is a general impression of Minority Institutions as both small in size and in purpose (mission and scope). Clearly, as presented already, resources are more limited in terms of people, facilities and money. However, this does not mean that, first rate research and education is not pursued nor that it cannot be achieved. Indeed by no means! In general, faculty in MI's are not as recognized as those at the major "research" institutions and this is largely due to the external perception of MI's. There is a prevailing perception of MI's as small which is often interpreted to mean "not very significant". There is also a perception that the overall quality (whatever that means) of both the faculty and student body is of a lower quality (that word, again!) than those in the majority research-oriented institutions. Of course, nothing is farther from the truth! The impact of such external perceptions or stereotyping can be far reaching -- affecting both the attitude of those without and those within Minority Institutions. For example, it appears to influence the thinking of those in MI's --- to the point of accepting some of these stereotypical views. Both undergraduate and post-graduate students seem to accept a view of inferiority to the point that they expect lower standards. Even so, the administration in MI's also tend to be limited in vision and therefore often do less -- or aspire to lower goals. In some cases, the university administration actually impedes the success of the faculty by taking less active roles in promoting the work of their faculty, and in fact tend not to assist faculty in the pursuit of high profile research and curriculum development ventures. In summary, both external and internal perception of the mission, ability and quality of research and educational goals work together to put the faculty at typical MI's at a competitive disadvantage.

Level of Compensation

The level of compensation at MI's is not attractive. Given the demands on both time and the myriad of both professional and service activities they are engaged in, the level of compensation should be comparable to those at the majority research-oriented universities and colleges. Faculty at MI's typically receive up to 10 to 20 percent less than their comparable counterparts. For example, a difference in annual salaries of more than $13,000 at the Assistant Professor level (in essentially the same geographic area) was determined in one case. This disparity in compensation levels is even more difficult to fathom when one considers that the faculty at the MI taught six courses during the school year as compared to the three courses taught by the faculty at the majority university.

SOLUTIONS

It is clear that Minority Institutions fill a special need in this country. In fact they provide for a special group of citizens and ethnic groups in the United States. Because they have a special niche it is important to ensure that the quality of education provided at these institutions is first rate. If Minority groups feel that institutions associated to them are second rate, feelings of neglect and inferiority are apt to surface. Besides, it is in the best interest of this country that every citizen has the opportunity to receive a good educational experience -- no matter where they choose to study. Furthermore, because MI's are small in size, it would not require a great deal of resources to effectively address the problems that they presently have. This will, in the long run, make this Country more competitive since all its institutions of higher learning will be operating at their optimum level. Given the above, and the fact that anything worth doing is worth doing well, the following actions will contribute in significantly improving the quality of research and the educational experience in Minority Institutions.

1) Development of well-defined donation programs that support the acquisition of specialized research and educational equipment. This will help to provide special (usually very expensive) equipment to augment the moneys allocated for equipment through state funds. This can be very effective, for example, when computer manufacturers donate their equipment and software for use at MI's.

2) Establishment of Faculty Loan programs from industry. This will be beneficial in two ways: It will allow professionals in industry to provide students and faculty with the industry's perspective. Students will therefore be exposed through this interaction, with skills necessary to survive when they graduate. On the other hand, a Faculty Loan program will help to reduce the already very heavy teaching loads in the MI's. Faculty will benefit from this quite significantly. They will be able to teach more effectively because the teaching requirements will be more manageable. If the teaching load and the research climate is improved, it seems that more qualified individuals would be attracted to seek employment in MI's.

3) Minority Institutions should group themselves into consortia. This would increase their visibility and help them to acquire the critical mass needed to seek and obtain more meaningful nationally recognized research projects. In fact, MI's are beginning to see the wisdom in grouping into consortia and are reaping the benefits of such interrelationships. Consortia would also allow them to create inter-institutional research centers that can support several post-doctoral positions -- further improving their chances of obtaining high profile research activities. Further, better research facilities and equipment, there would increase educational opportunities.

4) Faculty research initiation programs should be introduced to encourage the development of research and studies dealing with advanced or emerging technologies. Without a research initiation program, it is difficult for faculty to keep up with evolving technologies -- especially in this day of information explosion and rapid technological advancement. The funding for such programs should not require the usual matching funds; else the whole program will be self defeating. Some funding agencies do not appear to understand that MI's, because of their smaller size, cannot match funds at the same levels as the larger, well established institutions. For example, providing a Department with a $1 million grant that requires 100% matching is meaningless if the Department only has $50,000 to match. Industry and private groups can be effective in this regard by providing, within the MI's special funds for research initiation.

5) The generally lower salaries at MI's needs review. Bluntly put, there should be a general increase in salaries.

6) Along with establishing a Faculty Loan program, there should also be funds allocated for supporting both graduate teaching and research assistantships. The benefits of such a program cannot be overemphasized.

7) Periodic fully supported summer sabbaticals devoted specifically to curriculum review and development should be established. This would allow for the reasonable integration of advanced and emerging technologies into the curriculum and would facilitate and expedite the process of such integration. It usually requires a lot of effort to accomplish this efficiently when one is chasing after one thousand other things. If the graduates we produce are to be provided with the necessary tools to enter the job market, then we must invest in this faculty development activity. This will be resources put to very good use.

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USE OF MULTIMEDIA TECHNOLOGY IN ENGINEERING INSTRUCTION

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Abstract

This paper presents the development of multimedia technology and its utilization in the instruction of civil engineering topics including those in water resources and environmental engineering at Southern University.

The College of Engineering at Southern University has an outstanding track record in providing opportunities for under-represented minorities to pursue careers in engineering. Pipeline activities include an Engineering Summer Institute that furnishes prospective engineering students an early exposure to the field.

Southern, along with Cornell, Hampton, Iowa State, Cal Poly, Stanford, Tuskegeee and the University of California at Berkeley are members of the Synthesis Coalition, an engineering education coalition funded and established by the National Science Foundation to improve the quality and quantity of undergraduate engineers. A major thrust of this coalition is the use of multimedia case studies in civil engineering projects. We plan to spend the next two years developing interactive multimedia applications with video and sound narrations for MS-DOS, Macintosh and Unix based formats. Materials developed for elementary and secondary school students will be designed in such a way that they serve to stimulate interest in civil engineering and to motivate students to take the appropriate college preparatory curriculum.

Introduction

Southern University and A&M College is one of the largest of the Historically Black Colleges and Universities in the nation. The College of Engineering is about forty years old and consist of more than one thousand students in five departments. Recent downturns in the State and National economies have left the University with little money for capital construction and renovation projects. Because of laboratories that grew older and remained only marginally adequate, the College of Engineering and Department of Civil

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Engineering sought innovative means of enhancing laboratory experiences for our students.

Our initial efforts involved the development of computer-assisted-instruction software for the College of Engineering's 4341 mainframe computer. Faculty members and students developed a database of problems and solutions for sophomore level engineering science courses in circuit analysis and engineering mechanics. Graphic capabilities were limited and little actual interaction existed. In 1989, the College established several MS-DOS based micro-computer laboratories with 80286 and 80386 processors. These computers were primarily used for computer-aided-design, word processing, spread sheet applications and presentation graphics. As software became more sophisticated and the amount of RAM was increased, other applications in computer based learning were adopted.

In 1990, the National Science Foundation funded the Synthesis National Engineering Education Coalition. This coalition was charged with improving the quality and quantity of undergraduate engineering education in the United States. The coalition of eight colleges include Cal Poly at San Luis Ibisbo, Cornell University, Hampton University, Iowa State University, Southern University, Stanford University, Tuskegee University, and the University of California at Berkeley. Four thrust areas were identified to fulfill the NSF charge. These areas are 1) systematic curriculum reform, 2) supporting technologies or tools, 3) pipeline activities and 4) linkages with industry and other universities. This paper concentrates on activities at Southern University associated with the supporting technologies thrust area.

Courseware Studio

The philosophy of using state-of-the art technology to deliver knowledge is not new to engineering faculty. Faculty have tried for many years to improve the application of technology associated with the presentation of courseware. However, few engineering faculty members have formal training in educational delivery pedagogy. The supporting technology working groups within the coalition focus on helping the technically proficient faculty with 1) the identification of appropriate technologies, 2) becoming proficient in programming applications of this technology and 3) critical review and evaluation of the materials created.

The current student population has grown up in a media intense society. They are able to see, hear and touch most things that maintain their interest.

Likewise, the academic subject matter that also stimulates these senses are more likely to provide experiences which translate into knowledge. Much of our vision for the future of engineering education includes an evolution from chalkboard and lecture to one of interactive multimedia presentation and case studies with professorial coaching.

Each coalition university has established a courseware studio. The capability of each studio varies. The basic expectations of each courseware studio include the ability to 1) locate and retrieve subject matter from national electronic databases, 2) scan still photographs, slides and documents, 3) program various multi-media application software packages for DOS, Macintosh, RISC, and other Unix based environments, 4) provide expertise on the artistic and ergonomic concerns involved in computer based learning, and 5) a faculty member with engineering expertise. The courseware studio personnel have the ability to help in locating appropriate video clips and sound narratives. In addition, they are also proficient in operating equipment required to incorporate this material into a multimedia presentation.

In an ideal situation, the faculty member can enter the courseware studio with a concept for improving educational delivery and leave with a plan and schedule for developing a multimedia presentation or case study. His design team may consist of other faculty, graduate students, computer programmers, graphic artists, musicians, educational faculty advisors and student users. The development process is iterative and the amount of time required to produce a presentation varies with the project complexity and the level of production quality required.

Faculty Involvement in the Process

Faculty members are expected to generate creative ideas on courseware presentation. Current faculty projects include using linear slide presentations to enhance a lecture, the development of non-linear hyper-text case studies and the development of interactive graphic software packages that assist the learning process without diminishing the student's appreciation for theory and fundamentals. More advanced projects underway will incorporate animation of laboratory experiments followed by a video representation of the actual laboratory experiment concluding with a video representation of the actual phenomenon. The faculty are expected to come to the experts in the courseware studio with sound academic based pedagogy in his discipline. He is expected to become an active member of courseware design team and develop skills that diminishes his reliance on the courseware studio experts. As these skills are improved and evaluation and revision take place, this professor becomes the newest advisor and consultant in the courseware studio.

Student Involvement and Evaluation

The courseware studio focuses on presentations and interactive applications that possess on-line help as the major reference source to the student. A fifteen minute to one hour introductory lecture is presented when the student is initially introduced to the software. A concerted effort is made to have all interactive packages operate similarly. The use of buttons and menus are widely accepted standards that many students are familiar with.

The critical evaluation of multimedia presentation is important in determining the feasibility of the original concept and the degree to which learning is increased or improved. The end user of the presentation or case study is the student. We expect all users to recommend changes and assist in revisions to the presentation. As the concept advances, students will eventually author and edit the multimedia courseware that they use.

The interactive multimedia presentation may have its greatest impact on those students that are still in pre-college curricula. Most elementary school children readily identify with the roles of doctors, lawyers and accountants in society. Many of these same children have no idea of what engineering is and what engineers do. The portability of current multimedia technology offers our profession an opportunity to replace dull and lifeless brochures and pamphlets with diskette presentations. These type presentations should allow the student to explore the profession and demonstrate practical applications of mathematics and science. They also should consist of sound narratives and video clips describing the engineering profession and showing a variety of exciting engineering works. This type of presentation could be particularly helpful in encouraging women and under-represented minorities to prepare for careers the profession.

Sharing the Technology and Materials

The Synthesis Coalition is establishing the National Engineering Education Delivery Systems (NEEDS) database to provide a repository for electronic educational courseware. Courseware developers desiring to share materials with others can submit material to NEEDS for peer review and technical evaluation. If the material is deemed meritorious, it will be placed in this national database.

Several problems remain unsolved in the issue of multimedia technology application presentations and case studies. A standards group exist to establish recommendations for technology standards, copyright issues, cataloging and management of intellectual property. The coalition expects to resolve these issues over the next two years.

Conclusion

Multimedia applications and presentations will dramatically change the way knowledge is imparted to todays engineering student. The growth in technology provides educators with the opportunity to provide customized instruction to each student and enhance the process of learning. The ability to communicate these applications over national networks provide important opportunities to collaborate, evaluate and perfect the art of engineering education.

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RECOMMENDATIONS